Combining Forces - Advancing Facilities Management & Construction through Innovation Series

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Understanding the Construction Business and Companies in the New Millennium

Kalle Kähkönen & Martin Sexton

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Understanding the Construction Business and Companies in the New Millennium

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Preface

The new millennium is producing, confirming and extending complex, systemic challenges for the built environment and the construction industry. The profound demands of sustainable development and globalisation are but two examples of changes which are transforming the strategic intent and operational activity of nations and companies. These challenges are demanding a thorough review of the assumptions on which competition and performance have been traditionally based.

The organisation and management of construction is moving toward a model founded on intense, more open, interaction between parties. Performance and competitiveness is being reconceptualised and operationalised through a systems paradigm; be it the organisational unit (for example, regional innovation systems, global alliances and partnering arrangements); the procurement regime (for example, PFI or PPP); or production (for example, off-site manufacturing). It is no longer credible to operate in a closed, linear way. The era of compartmentalised contributions from different construction actors is vanishing and, in its wake, new opportunities are opening up through greater transparency and closer collaboration and cooperation.

This volume articulates the current landscape, identifying new trajectories and pressures facing construction and construction companies, and the new management concepts and tools which are shaping, and responding to, this dynamism of the new millennium. The volume is structured into six sections: characteristics and performance of modern construction business; shaping companies with new managerial solutions; organisational studies and innovations; human resource management; means for improved competitiveness; and, industrialization in construction. Each section provides a survey of current and future issues and, perhaps more importantly, a stimulus to provoke us to evaluate our own thinking and own research, and to envision novel, appropriate futures which address the pressing challenges of this new, exciting, but uncertain millennium.

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Section I

Characteristics and Performance of Modern Construction Business

Design and Implementation of Performance Measurement Systems for Benchmarking in the Construction Industry

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Abstract

Performance measurement is an essential element of business management. It provides the necessary information for process control, and makes it possible to establish challenging and feasible goals. It is also necessary to support the implementation of business strategies. The effective implementation of performance measurement systems is not simply a matter of selecting the right measures, but it also implies a much deeper change in decision-making and also in the learning approaches adopted in the organization. In the last few years, there have been some initiatives concerned the establishment of performance measurement systems for benchmarking in different countries. The objective of this paper is to describe the scope of those initiatives and discuss its potential role for benchmarking construction companies, specially those involved in the design and implementation of new operations management ideas. This investigation is focussed on four initiatives, carried out in Brazil, Chile, the UK and the USA. The paper concludes by proposing some further directions on this research topic.

Keywords: Performance measurement, benchmarking, construction industry

1. Introduction

Despite the importance of performance measurement, it has not been widely implemented in construction companies and information on the performance of the construction industry as a whole is also scarce. The lack of performance measurement is still a problem that affects the construction industry in general. This is related to a great extent to the attitude and lack of training of managers [1]. In fact, several companies measure and control a wide range of project variables, but only a few have performance measurement systems that provide key information for supporting decision-making [2].

Moreover, some companies have too many measures, most of them related to supporting rather than critical processes [3]. This tends to make it difficult for the company staff to understand what should be the priority and also to define the key indicators that should be used for comparison to other companies [4].

Performance measurement must shift from the traditional historical orientation, which looks only at the results and their main causes. Instead, the causes of the desired performance must be identified beforehand and then the measurement and control process that maintain these causes within prescribed limits can be designed [5]. This new focus is concerned with identifying goals and linking them to the critical factors required to achieve them.

However, the effective implementation of performance measurement systems is not simply a matter of selecting the right measures, but it also implies a much deeper change in decision-making and also in the learning approaches adopted in the organization.

An important role of performance measurement is to enable the company to do benchmarking. Benchmarking is a systematic process of investigation and learning of the performance against other similar organisations in key business activities. Then, lessons learned from the best practices should be used to establish improvement targets and to promote changes in the organization [6,7]. Benchmarking must be an integral part of the planning and on-going review process to ensure a focus on the external environment as well as to strengthen the use of factual information in developing plans [8].

The greatest benefits of the benchmarking process is the way that work gets done, rather than results, and the involvement of managers in the process [9]. Besides, it is used to improve performance by understanding the methods and practices required to achieve higher performance levels [8]. The general purpose of benchmarking is to encourage continuous learning for both managers and organisations, being used as an assessment tool [7]. Garvin [9] argues that the benchmarking process can promote a fertile source of ideas, but it only will occur in a receptive environment.

This environment can be created through Benchmarking Clubs, which involves a set of similar companies aiming to compare results and share practices. One of the propositions is that the benchmarking clubs have some similarities to communities of practices, which are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in a specific area by interacting on an ongoing basis [10].

The communities of practice are one mechanism, which involves the process of "Legitimate Peripheral Participation" [11]. This learning approach is broader than simply "learning by doing" or experiential learning, being also known "Situated Learning" [12]. According to Brown et al. [12], what the people pick up is a product of the ambient culture rather than of explicit teaching, and this is called “process of enculturation”. For these authors, learning and acting are interestingly indistinct, learning being a continuous, life-long process resulting from acting situations.

In recent years, there have been some initiatives concerned with the establishment of performance measurement systems for benchmarking in different countries, such as Australia, Brazil [13], Chile [2], Denmark, the UK [6] and the USA [14]. Such initiatives typically aim to (a) offer some guidance for performance measurement, (b) provide some benchmarks that could be used by individual companies to establish their business goals and objectives, and (c) identify and disseminate best practices in the industry.

The aim of this paper is to raise some key issues related to the use of performance measures for benchmarking in the construction industry, and identify some key factors on the effective design and implementation of such performance measurement systems.

2. Initiatives of PMS for Benchmarking in the Construction Industry

Four initiatives were investigated: (a) KPI - Key Performance Indicators from the UK; (b) National Benchmarking System for the Chilean Construction Industry; (c) Construction Industry Institute Benchmarking and Metrics from the United States of America; and (d) Performance Measurement for Benchmarking in the Brazilian Construction Industry. Information about those initiatives was obtained in their web sites, from published papers, and also from interviews carried out with people involved in their implementation.

2.1 Key Performance Indicators (KPI) in the United Kingdom

The KPI Programme was launched by the UK Best Practice Programme in 1998. This programme is supported by the government, through national and regional offices. Recently the Constructing Excellence body was created, which is the amalgamation of Rethinking Construction and the Construction Best Practice Programme (CBPP). The Construction Excellence aims to achieve a step change in construction productivity by tackling the market failures in the sector and selling the business case for continuous improvement [15].

Four integrated programmes were created aiming to achieve the delivery of Constructing Excellence’ strategic objectives: (a) **innovation**, which aims to identify and promote tomorrow’s best practices; (b) **productivity**, which aims to improve the competitiveness of the UK construction industry; (c) **best practice knowledge**, which aims to create continuous improvement through the exchange of best practice; and (d) **engagement**, which aims to work with people, businesses and organisations to change the culture of the industry. These programmes are complementary and in each one there is a set of integrated programmes activities [15].

Nowadays the Key Performance Indicator (KPI) makes part of the Productivity Programme. The first set of KPIs was produced in November 2000, and the current set of KPI is based upon projects completed in 2002 [16]. The design of the first set of KPI was the result of an initiative involving extensive reviews by a panel of experts and the publication of a report. The set of KPIs is annually updated by the Construction Best Practice Programme [15].

For the implementation of the KPIs, companies receive a support handbook and guidance for measurement and access to an online software. The companies are responsible for collecting data, introducing them in the database, and for updating the project data. This software supports the analysis of the project performance in relation to the benchmarks. The companies involved can also access reports and wall charts, which contain graphs of performance (ranking curve and radar chart) for 10 key issues for construction such as client satisfaction, cost and time. The wall charts show the benchmark scores and allow an organisation's score to be benchmarked against a large sample across industry.

A few hundred companies have been participating in Best Practice Knowledge Programme, on a voluntary basis for demonstrations projects. The companies present their projects, which are reviewed by a panel of experts. Two main reasons have encouraged these companies to enter the KPI programme: marketing of the company and the opportunity to improve their performance.

The companies involved can participate in a Benchmarking Club and are given access to information form all main Benchmarking initiatives, clubs and organisations that provide services to the construction industry [15]. Each Benchmarking Club is a forum for individuals to learn about the principles of best practices, while creating a culture and a local support network for supporting continuous improvement. The Clubs are local services, and each new Club is started by the drive and vision of a person or persons in the local construction industry [15].

2.2 National Benchmarking System for the Chilean Construction Industry

The National Benchmarking System was developed by the Corporation for Technical Development (CDT) of the Chilean Chamber of Construction, with the support of the Program for Excellence in Production Management of the Pontificia Universidad Católica de Chile (GEPUC). This initiative started in 2001. By comparing key performance indicators, the CDT hopes to identify best practices and generate short-term improvement opportunities for participating companies [2].

The selection of performance indicators was based on previous studies that included an extensive literature review and empirical research [17,18]. Initially, there were over 30 performance indicators that were analysed in several meetings involving company representatives. The indicators were later prioritised by the participants in a seminar with the purpose of reducing the number of indicators, based on the experience and needs of the companies. The aim of this initiative was to use this set of indicators to promote continuous improvement and benchmarking between companies [19].

The set of indicators is concerned with five sub-sectors of the Construction Industry: (a) high-rise building; (b) low-rise building; (c) civil works; (d) heavy industrial construction; (e) light industrial construction. For each sub sector, four main indicators were collected and analysed. By 2001, the National Benchmarking System of Chile had in its data base 120 projects provided by 22 Chilean companies. All companies are members of the Chilean Chamber of Construction and they have committed themselves to keep using the performance measurement system until the end of the project [2].

For the implementation of these indicators, the companies involved received a support guidebook and had access to computer software, which enables comparisons to be performed [2]. The National Benchmarking System use both quantitative and qualitative tools for data analysis, such as: (a) mean; (b) ranking curves; (c) radar graph and (d) tables displaying companies result. Also, a correlation analysis is carried out on the data using Pearson’s correlation, factor analysis and multivariate linear regressions [2; 20].

An evaluation system for managerial practices has been recently developed as an additional part of the Benchmarking initiative [20]. This system seeks to incorporate qualitative data to complement quantitative performance indicators. It compares managerial practices, identify relationships between performance data and determine industry trends.

2.3 Construction Industry Institute Benchmarking and Metrics

The CII Benchmarking and Metrics Programme started in 1993 [14]. It aims to provide performance norms to the industry, to quantify the use and value of best practices, and to help focussing CII research and implementation efforts. A committee of industry representatives working with the CII staff has developed its policy and is in charge of overseeing the execution of the program. This committee has defined critical performance measures that can be used in practice and developed a strategic approach to CII's collection, analysis, and dissemination of industry data. The Benchmarking and Metrics Committee meets on a regular basis for continuous development and improvement of the program [21].

The first data collection of CII Benchmarking and Metrics was in 1996 and the current set of indicators was established in the fifth review, in 2000 [14]. The CII Benchmarking and Metrics program collects the project data as an ongoing process through its website. The web site has an easy-to-use interface and is designed to collect data over the life of a project [21]. Participants receive real-time evaluation on their projects’ performance using the web-based Progress Key Report.

Besides the web site and guides to support the implementation of the system, this program provides annual training to the Benchmarking and Metrics Programme company members, aiming to improve the reliability of the benchmarking process [21]. The system is also used to analyse the impact of CII Best Practices on projects, but there is limited analysis or correlations on the management practices that might lead to improved project performance.

In January 2003, CII's benchmarking database had over 1100 projects from more than 70 CII owner and contractor companies, 11 ECI (European Construction Institute) companies and 4 BMPPs (Benchmarking Participants). This represents $55 billion in total construction cost. The projects are from the heavy industrial, building, light industrial, and infrastructure industry groups, with the majority representing heavy industry [21].

2.4 Performance Measurement System for Benchmarking in the Brazilian Construction Industry (SISIND-NET Project)

The SISIND-NET Project is a fairly recent initiative, initiated in April 2004, that has been developed by the Building Innovation Research Unit of the Federal University of Rio Grande do Sul (NORIE/UFRGS) and the Association of Construction Companies from the State of Rio Grande do Sul (SINDUSCON/RS), with the support of the National Council for Scientific and Technological Development. It involves the design and implementation of a performance measurement system for benchmarking in construction companies from the State of Rio Grande do Sul. Its aims are: (a) devise a web-site for collecting and disseminating data, including a web based tutorial that can be used for training; (b) create a learning environment that will enable companies to share both qualitative and quantitative information related to their performance and best practices; and (c) promote workshops and training courses in different places in Brazil, aiming to disseminate and implement the set of measures.

The first stage of the SISIND-NET Project was the definition of the set of measures for benchmarking, based on the international experiences [14, 6, 2] and past studies in Brazil [22, 23]. Four criteria were considered in the definition of measures: (a) previous use of the measures by companies; (b) possibility of performing external comparison; (c) generic measure enabling the application in different projects context; and (d) mix of leading and lagging indicators. Several meetings involving both representatives of the companies and members of the research team were carried out for defining the set of measures. In each meeting a sub-set of measures was discussed, including their objectives, formulae, and data collection and analysis procedures. The final version of the set of measures was defined in the end of August 2004.

So far, eighteen construction companies from the State of Rio Grande do Sul have been involved in this initiative, most of them from the residential, commercial and industrial building markets, establishing the first Benchmarking Club in Brazil. A training course was provided for the companies’ staff involved in the implementation of performance measurement in the companies. In October 2004, the implementation process was started and the data began to be sent to the database by the companies. Currently, the companies are starting to share results and practices in the Benchmarking Club, through monthly meetings. A web-based online tool for entering and processing data will be available for companies until March 2005.

One important result of this initiative is the participative process that has taken place in the Benchmarking Club. Through the meetings, the companies have participated in decisions concerning the choice and definition of measures, including the negotiation of data collecting criteria. As a consequence, the representatives of the companies involved understand well the set of measures and now they are aware concerning the relevance of each measure for them. This is an improvement in relation to similar initiatives carried out in Brazil.

As a consequence, the preliminary assessment of the involvement of the companies in the SISIND-NET Project indicates that they perceive this as a favourable environment to introduce and internalise the use of performance measurement. This process has motivated the systematic data analysis, due to the companies' interest of comparing performance and sharing practices with other companies in the same and different sectors.

In the following stages of this project, the research team intends to explore the learning opportunities provided by this initiative. This will be made by understanding the learning processes that is going on in the Benchmarking Club and also by the transfer of knowledge in a small group of construction companies. One of the main propositions of this study is that the process of learning of the Benchmarking Clubs can be motivated by using concepts of communities of practices, since it involves collective or collaborative learning in an informal manner. The potential of the Benchmarking Club for triggering managers' knowledge as well as for promoting organizational learning will be investigated.

3. Lessons learned from the benchmarking initiatives

Based on the experiences of benchmarking initiatives in UK, Chile, USA, and Brazil some key issues for the design and implementation of benchmarking systems were identified. Firstly, this kind of initiative demands a joint effort from several organisations, such as government, construction clients, individual companies, research institutions, and industry organisations. In the construction industry there are a number of barriers, due to its peculiarities, such as (a) construction is a project-oriented industry, each project is unique in terms of design and site conditions; (b) establishing a project performance measurement system and incorporating the measures into the company routine require a fairly intense effort; (c) the responsibilities for data collection, processing and analysis, in general, are not well defined at the beginning of the project; (d) each project usually has a different managerial team and the use of measures will depend on the capabilities and motivation of each manager [3].

In general, the set of measures for benchmarking should be simple and well designed in order to effectively support improvement initiatives. The set of measures must give a holistic, company-wide view including a mixture of leading and lagging indicators [24]. Table 1 summarizes the main set of performance measures adopted in each of the four initiatives. Although all sets involve a wide range of measures, some of them are common among the programmes, such as cost, time and safety. This suggests that such initiatives could be potentially involved in some kind of international benchmarking scheme.

As it is shown in table 1, the KPI and CDT programmes mostly involve lagging measures, based on outcomes. Such measures are important for accessing the success of strategies, but do not support the identification of improvement opportunities during the period for which the measure has been taken [24]. By contrast, the design of CII and SISIND-Net benchmarking systems includes a set of performance measures that can be used during the whole life of the project.

No measures related to suppliers' performance, employee satisfaction, site management, and quality management were found in CII, CDT and KPI initiatives. As these were considered to be of major importance for the Brazilian companies they were included in the SISIND-NET initiative.

The procedures for data collection should be also simple, aiming to facilitate the creation of the database and to make it simple to evaluate the project performance in relation to other projects in real-time. The four initiatives (KPI, CDT; CII and Sisind-Net) offer an interactive online tool for the collection and evaluation of the benchmarking measures. Such a tool allows the user to access an assortment of documents and provides immediate feedback for the Benchmarking Club members. Beatham et al. [24] suggest that the online tool must be used throughout the whole life of a project, in order to create continuous opportunities to analyse the results and to promote improvements. Another key issue of the implementation of the online benchmarking process is data confidentiality and security.

One aspect that has not been sufficiently explored by any of the initiatives is the alignment of the benchmarking measures to the company strategy. Therefore, Benchmarking Club members should be encouraged to design their own performance measurement system according to their strategy and capabilities, making sure that the set of measures is relevant and feasible for them. According to Hudson et al. [25], a strategic performance measurement system for small sized companies must be very resource effective and produce notable short-term results. In addition, it must be dynamic and flexible enough to accommodate strategic changes, which tend to be more frequent in small sized companies, which tend to have emerging strategies. For those authors, in practical terms, this means that the process should be iterative, in order to maintain the strategic relevance of performance measurement.

Table 1 – Comparison among the Benchmarking Initiatives (UK, Chile and USA)

Criteria		KPI (United Kingdom)	CDT (Chile)	CII Benchmarking & Metrics (USA)	SISIND-NET (Brazil)
Scope of measures	Lagging measures	Client satisfaction* Defects* Predictability cost* Predictability time* Profitability Safety Productivity*	Deviation of Cost by Project* Deviation of Construction Due Date* Change in Amount Contracted Rate of Subcontract Cost Client Complaints Efficiency of Direct Labour Accident Rate* Risk Rate*	Project Cost Growth Project Budget Factor Project Schedule Growth Project Schedule Factor Total Project Duration Change Cost Factor Recordable Incident Rate (RIR) Lost workday Case Incident Rate (LWCIR)	Cost Deviation* Time Deviation* Degree of Client Satisfaction (user) Degree of Client Satisfaction (owner) Average Time for Selling Units Contracting Index Ratio between the number of accidents and total man-hour input Index Non-Conformity Index in the unit delivery
	Leading measures		Effectiveness of Planning Urgent Orders Productivity Performance*	Total Field Rework Factor Phase Cost Factor Phase Cost Growth (owner data only) Phase Duration Factor Construction Phase Duration	PPC (Percentage of Plan Completed) Construction Site Best Practice Supplier performance (Sub contracted, material and design) Number of Non-Conformity in audit Degree of employee Satisfaction Training Index
Implementation	Positive issues	Online software for users Benchmarking Club	Online software for users Outlined system (qualitative analysis)	Online software for users Annual training Annual questionnaire for companies evaluation	Online software for users (in development) Benchmarking Club
	Difficulties	Availability of data and validity of data Do not offer opportunities for real time control	Commitment of companies Measures Standardisation Continuous measurement Keeping the project team	Commitment of the companies Implementation of improvement process based on the findings from the benchmarking program	Commitment of companies Continuous measurement
*Note: * measures that could be used if measured during the process*					

In terms of effectiveness, the KPI initiative in the UK is the only one that has been critically analysed in the literature, and the following difficulties have been pointed out:

- The KPIs are specific to projects and offer very little indication of the performance of the organisations themselves from a business point of view, apart from the customer perspective [26];
- It is important not only to use the right measures to measure the right things, but also to show the relationships between the different measures from a holistic viewpoint, since this is a way of identifying potential mechanisms for improvement [26];
- In general, the main difficulties in the whole process of the KPI programme are concerned to the availability of data and their validity [26];
- The most significant problem with the KPIs (in their current format) was that they do not offer opportunities for real time control. They are mostly designed to be used as post-result lagging KPIs. This kind of indicator is used only as a historic review [24].

Several companies in the benchmarking initiatives find difficult to start the implementation of measures, partly due to the lack of involvement of workers. Alarcón et al. [19] suggest that the implementation should start gradually with a small set of performance indicators that are relatively easy to measure. This might facilitate the development of a measurement culture within the organisation, which will facilitate future implementation, and then focus on critical processes.

The investigation of the four programmes indicated that some construction companies involved in those initiatives still have a limited view of benchmarking. They are simply interested in comparing their performance to other companies, especially from the same market segment. Such companies should see benchmarking as a source of new ideas, or a route to support performance improvement based on observed best practices. The information provided by benchmarking initiatives should enable a better understanding of the workings of business (their own or their competitors'), leading to improvement actions, instead of only being used for data comparison. Therefore, it is also important to promote training for the companies involved, including the communication of results, analysis of the evolution of the set of indicators, and encourage the exchange of practices and the creation of knowledge in Benchmarking Clubs.

4. Final Comments

This article has presented a brief description concerning the current stage of performance measurement systems for benchmarking the have been devised in four different countries (UK, Chile, USA and Brazil). The commonalities among these initiatives indicate that they potentially could be used for international benchmarking.

However, the social-economics realities and the construction sector environment among the four countries are different. Chile and Brazil have some similarities, which can promote good opportunities for sharing findings and best practices. These countries are characterised by the high number of small construction companies, large demand flotation, mainly in the housing-building sector and a very large informal market. In general, the companies in UK and USA tend to be larger and the construction sector is better organised. Then, the impact of these four initiatives in terms of supporting learning processes must be investigated taking into account differences in the cultural and social context.

This paper has pointed out some of the benefits, problems and limitations of the existing systems. The lessons learned should be used for upgrading the existing initiatives and devising new ones. A joint effort involving several organizations is necessary for the successful design and implementation of performance measurement benchmarking programs. Such initiatives should not be limited to data collection, but also provide data analysis and training, as well as enable the exchange of best practices among the companies. Moreover, the set of measures should be assessed and revised periodically, according to the needs of the companies involved.

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The effect of procurement on the integration of the supply chain within the construction industry

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Abstract

As time goes by, more and more companies within construction industry are moving away from traditional procurement route towards innovative procurement methods. In the UK, partnering framework, prime contracting, PFI or PPP, etc. are some examples of procuring the construction work differently than it used to be in the past years. One of the key elements in all these procurement methods is the management of the supply chain. Key questions discussed around this area are how to make partnering and other methods successful; how to select and appoint suppliers; how to manage the integrated supply chain; how to build trust; who will lead the whole process; etc. This paper will look into the different questions mentioned above by explaining the basic rules of supply chain integration including: understanding the brief; understanding the whole process of construction by each trader involved; early involvement of suppliers and sub-contractors; effective management and leadership for integrated supply chain; effective communication and feedback on performance; etc. This paper will define supply chain integration within the construction industry and incorporate some findings from of an industrial case study on above issues discussed with emphasis of the effect of the adopted procurement method on the integration of the supply chain. The paper is part of the Supply Chain Integration Project undertaken by researchers of the SCRI Research Centre at the University of Salford.

Keywords: supply chain integration, construction clients, procurement, power, roles.

1. Introduction

If we look at, generally, why there are many initiatives to improve the performance of the construction industry; a few responses are obvious. The most obvious one is the bad reputation of construction industry for not delivering the projects: in time, within budget, and with desired quality. On the other hand, these initiatives for change are somewhat responses to gain the confidence of dissatisfied client/customers/end users. What does the client want, has also become an area of research on its own, identifying the requirements and needs of the clients, specific to a project and overall from the construction activities, which includes: reduction in cost; improvements in profits; expenditure is kept within the budget limits; achievement of sustainable outcomes; predictability of construction programme, price, and quality; faster delivery than the competitors; development of a safe environment; etc. In reality, the above-mentioned client's wants are the aim and objectives (and if not then should be the aim and objectives) for all the participants involved in a construction project supply chain. But, on the other hand, these objectives cannot be realised if involved participants do not do any efforts to achieve them. And one of the ways to accomplish and get succeeded is to adopt integration and collaborative values and behaviour (mentioned here) as advocated by the research team here at Salford [1], and also by others within the construction industry such as Collaborative Working Centre of *be* (www.cwcltd.biz): FUSION; Fairness, Unity, Seamless, Initiative, Openness, and No blame. This paper will look into what sort of changes the new procurement methods and relevant initiatives have brought and are bringing within the construction industry with respect to achieving integration and collaboration within the involved organisations in the supply chain.

2. Supply chain integration through procurement

It is evident that the construction industry is becoming increasingly aware of the necessity to change current working practices and the attitudes they represent. Similarly, a number of organisations and individuals within the construction industry are already moving towards supply chain management through the use of partnering, framework agreements and techniques to rationalise their supplier base [2].

Hall et al. [3] advocate that the one of the enablers of supply chain integration is the chosen procurement route (which could be either PFI, partnering, or design-build-finance-operate). This is because it provides the formal links within which supply chain integration is attained and sustained. In their view, any consideration of any formal contractual terms is not only a legal tie but also a way in which knowledge and activity flow between organisations involved within a construction project. Akintoye et al. [4] support the above discussion by saying that when SCM in construction is adopted along with partnering and TQM concepts, it would successfully address the major current problems faced by construction industry overall and its clients specifically. Benheim and Birchall [5] also consider new procurement methods as a tool to integrate the construction supply chain, because it provides openness, trust, cooperation, harmony of decisions, sharing of benefits, intangible and long term investment, collective working routine, and a fair allocation of risk.

More than ten years have now passed since the publication of Sir Michael Latham's report 'Constructing the Team' [6] and seven years since 'Rethinking Construction' [7]. Many organisations have taken up the challenge to introduce new procurement initiatives such as Partnering into their organisations. There have been varying degrees of success and failure. There is also an opportunity to gain from this experience by capturing the lessons learned to avoid duplicating mistakes and allowing organisations to replicate success. The objectives of involved organisations should be to:

- Prepare themselves for the change in culture;
- Learn from examples what goes right and how it could go wrong;
- Define the key elements of new procurement initiatives;
- Get the right people involved to define objectives;
- Design a fair and auditable procurement process, and last by not the least is;
- Be equipped to set up effective cost controls.

There are other issues, which the organisations involved should take care, including:

- Will these new procurement initiatives work for the organisation?
- What things go right and how it could go wrong?
- When things go wrong, how to correct them?

Every organisation will have unique wants and needs in making the effort to implement the initiatives. There is a clear need for:

- An understanding of best practice in procurement methods;
- A process for applying EU procurement rules to meet legal requirements and still get what you want;
- Designing a best value evaluation model;
- Setting up effective controls and managing budget with open book accounting; this may include questions such as Why is an open book approach important? What are the key elements of implementing and operating financial controls? And How to get what an organisation wants and making it work?
- Developing relational capabilities and leadership skills as an organisation and among individuals in the organisation, beyond the level related to traditional procurement.

3. Construction clients' role and power in integration

Clients have played a central role in construction, and has been studied since long time [8], including with regards to supply chain integration [9]. Some authors have criticised and called for change in clients' procurement strategies and tendering procedures [10, 11]. Briscoe et al. [12] argue that clients have a critical role for integration of the supply chain because it is the client that makes the initial decision to procure construction works and the way in which procurement takes place. This, in turn, influences the degree of supply chain integration and ultimately the overall success of the project. Therefore, they concluded that the client is the most significant factor in the success of supply chain integration through adoption of new procurement routes and the client must develop practices that facilitate such integration if the construction process is to be improved. Another conclusion, which they drew, was if the long-term relationships in the supply chain are to be nurtured. Changes in the client's traditional approach will often be necessary and a clear change programme will need to be established specially in the realm of procurement to turn from adversaries into partners [13].

London and Kenley [14] also concluded the similar statements from their research by stating that clients can impact on construction supply chain and their organisations, through the initial procurement decision and demand system. The client firms need to understand their supply chain, their own role in proactive management of a project supply chain, and the importance of new procurement initiatives. They also argue that often being the initiators of the supply chain, client firms have integral part within the whole chain and they potentially can have the greatest impact on the supply chain through their procurement decisions. From this position clients can exercise their authority upon the supply chain to achieve better value [15]. Clients also need to understand that these new procurement initiatives have potential to result in:

- Flexible and adaptable facilities;
- Maximise use of what they've already got;
- Start immediately, move fast and finish early;
- Minimise capital cost;
- Minimise whole life cost;
- Greater predictability;
- Think long term against short term pressures;
- Committed and involved supply chain participants.

3.1 Typology of construction clients

But now we should ask a question: are all clients ready to take up this role? According to Cox and Ireland [16], the majority of clients within the construction industry are not in a position of dominance over the supply chain because of the nature of their ad- hoc construction profile combined with their misunderstanding of the marketplace. Only the regular clients are in the better position to be able to leverage the supply chain effectively and implement integrated supply chain management concept successfully through introducing new procurement strategies such as partnering, strategic alliances etc.

First the possibilities and extent to develop supply chain integration from a client perspective depend on the specific construction sector. In some sectors, clients have a position that enables them to take up supply chain integration, and in some sectors not, for instance:

- Housing: Clients are customer, and do normally have no influence on the supply chain;
- Commercial building: Clients are operator and/or co-developer of buildings, and thus can play an active role in the supply chain if they want;
- Infrastructure; Clients are service providers to the public, and often has extensive influence on these services and on other service providers, so this kind of clients is often able to exercise considerable authority upon the supply chain.

Second the possibilities and extent to develop supply chain integration depend on the characteristics of a client, including:

- Buildings portfolio owner or singe building owner;
- Experienced client or not;
- Professional client or not;
- Institutional or individual client;
- Public or private organisation;
- Local or international organisation.

3.2 Factors influencing construction clients' roles and power

In addition to the type and position of clients within the construction sector they are in, various external factors are affecting clients' roles and power vis-à-vis their supply chains, including size of the suppliers market, global or local suppliers market, influence of regulations on clients (public or private), and market share of the client, e.g. large clients dominating other smaller clients in particular client markets, having major influence on suppliers, and thus the ability to exercise power on suppliers.

Based on the above notions, including the type of sector and clients, and external factors, clients that are able to play a dominant role can exercise power upon the supply chain, and develop procurement strategy aimed at supply chain integration. In this paper, such a client is observed to play a dominant role and enforce integration upon the supply chain; or even mobilise own integrated supply chain, e.g. through framework agreements with contractors, specialists, suppliers, architects, structural engineer etc., such as BAA's framework agreements.

4. Achieving effective integration through procurement

Proverbs and Holt [17] advocate that supply chain downstream (including principle contractor, subcontractors, material suppliers, etc.) should be targeted as a mean of effectively reduced overall construction costs. They refer it as 'downstream strategic alliances' (DSAs). They also advocate early involvement of subcontractors and suppliers in the similar manner as of early contractor involvement. This would give an opportunity to downstream participants to offer their expertise, which could result into potential cost savings. Such integration would come through introduction of new procurement policies and also help converting suppliers from providers of product to providers of services. Often such new procurement methods have a long-term strategic perspective and relational aspects to it [18, 19]. Many of these clients create multi-project environments implying multi-project procurement and repetitive tendering arrangements with contractors [20]. In this perspective contractors are observed as partners adding value to the client's business instead of merely doing projects for the client [21].

4.1 The 'aspirational' move

The historical or traditional procurement process (see Figure 1) was the only acceptable process in the construction industry until around a decade ago. The process had made a specific culture within the construction industry which contributed towards the inefficiency of the construction process overall. The reliance was only on the lowest cost tenders. Other concepts included were; designers should design, constructors construct, and maintainers maintain; no formal collaboration and no formal flow of information; a free market would drive efficiency; suppliers won't offer what they can't afford; etc. The big issue, which prevailed, was that winners of the project either misunderstand project, or make mistakes. The phrase that can best summaries the whole process could be 'You don't know what is excluded until too late!'

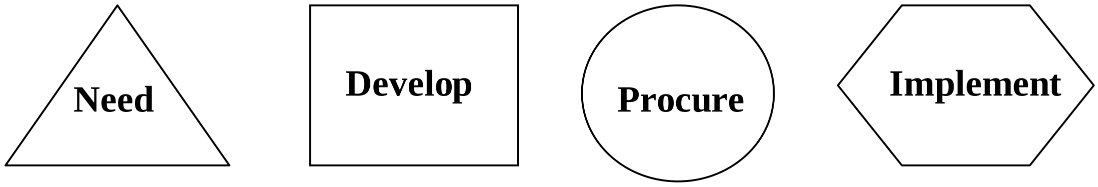

Figure 1: The Historic Procurement Process

Now here comes a period where new procurement processes are being initiated within an organisation and the process can be considered as a transitional process (see Figure 2). This process includes 2 Stage Selection/Tier 1 Partnering concepts. These concepts results in following:

- Implementers have early chance to understand needs of the client/customers;
- Designers and implementers can discuss options together, which could include Implementers providing “constructability”, critique; etc.

But there are still issues that prevent the process to be carried out in its full spirit. These include:

- People don’t share ideas within the project development team;
- Ongoing supplier relationships could be undermined while new initiatives are introduced
- Contractors’ supply chain is not involved at the outset of the project. In fact, the contractor does not have an integrated supply chain; etc.

In order to define how effective this process is, not much could be commented except ‘Good ideas undermined by lack of commitment’.

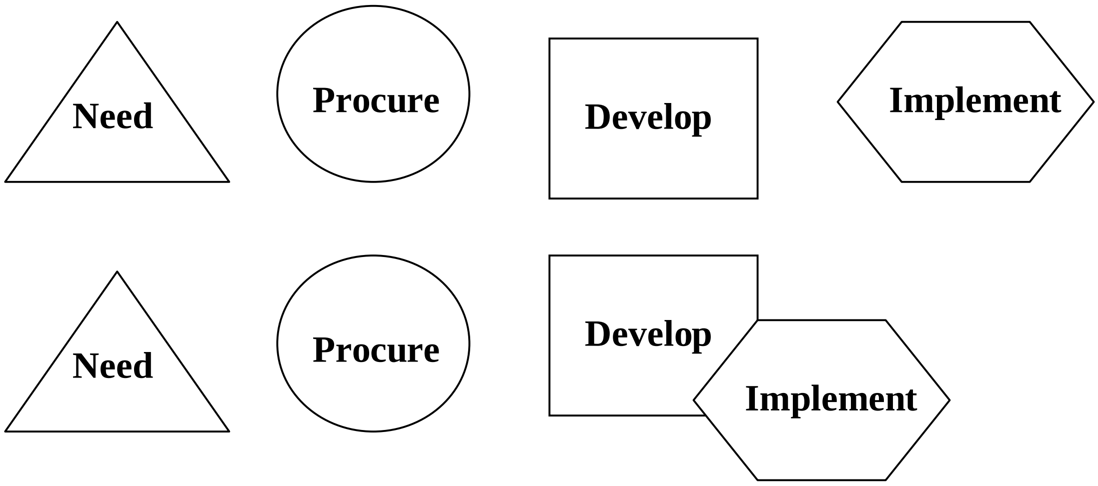

Figure 2: The Transitional Process

The most desirable next step is to move towards the aspirational process (see Figure 3), which is based on the whole concept of Integration and collaborative working within the whole supply chain. The concept propagates:

- Pre-selection and appointment of long term supply chains partners;
- Early formation of project teams - involvement and commitment of all principal partners at the outset of a project;
- Shared goals, objectives, and outcomes of all the supply chain partners; etc.

Since, the whole process is like a ‘culture shock’ for the construction industry, a few issues are

- No common understanding of these new procurement initiatives;
- People don’t realise how radical and different it is from the traditional and transitional processes;
- Requires faith and trust, leadership, awareness by client to positively and proactively exercise his/her authority in order to achieve the full benefits of the process; etc.

The bottom line is that only a small number of companies are ready and willing to take such process on board.

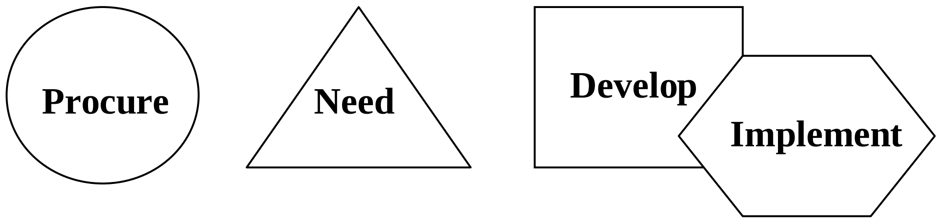

Figure 3: The Aspirational Process

4.2 The 'real-world' move

Various examples of strategic thinking and long-term structured action by clients in terms of their procurement policies and methods have shown positive effects on value and efficiency levels of construction work. In this paper the case of the integrated procurement of the upgrading of railway crossings in the Netherlands is presented as an example:

Around 2000 the Ministry of Transport, Public Works and Water Management took decision to increase safety of all railway crossings in the country dramatically, and reduce number of casualties to a minimum. This particularly applied to those crossings guarded without barriers, but only warning lights, particularly in rural areas. The decision implied that all 600 crossings without barriers throughout the country would need barriers within 10 years time. When the ministry was preparing the tender specificities of the crossings were discussed, general parts identified, and uniformity increased. In the tender one approach for all projects was defined based on a performance concept, which was standardised as much as possible. Criteria to bidders did apply to time and cost guarantees for delivery, and general specifications and safety conditions to the crossings only. Because of public building regulations, a solution was found to put the tender to the market by asking the complete market of contractors and suppliers for railway crossing for a bid, which came down to five certified firms. After discussion with all parties the entire project was assigned to the entire market. In order to keep the planned schedule and gains the condition was that the firms had to create a combined firm to execute the work. The firms did start a joint firm on one location with a single management. The work started in 2002, and still needed to be ready by 2010; implying the reconstruction of about 80 crossings per year. The Ministry had a fixed maximum annual budget. Payment was based on the actually delivered number of crossings per year. At the end of each year the progress was measured and evaluated against open book cost calculations followed by price negotiations. Due to the learning curve the first three years the number of crossings delivered rose from 40 to 80 to120, and the cost efficiency gain amounted to 30% over three year, which was used for annual price reductions and moderate increase profits for firms.

In this particular case, by revising its procurement strategy, the client organisation did not only manage to integrate the supply chain and achieve the planned cost levels and additional efficiency gains, but did actually integrate the complete suppliers market and all demand in this particular case on a national scale.

5. Discussion and conclusion

Green et al. [22] support the idea and make a concluding remark that 'within the context of integrated procurement approaches in construction, the conditions of mutual dependency will prevail across integrated supply chains. This will provide a significant break with the rump of construction industry. Clients may benefit through a more integrated services. Integrated supply chains potentially stand to benefit by competing primarily on the basis of innovation and expertise rather than cost. Construction firms are currently investing in new skills and the development of integrated supply chains for the purpose of competitive positioning. However, such trends are highly dependent upon a continuous flow of work of this nature'. This kind of interdependent co-development of integrated supply chains by clients and contractors (and specialists, suppliers etc) who are more or less equally powerful and dependent on each other is one path of supply chain integration in which issues such as trust and partnering, and sustaining multi-project procurement and repetitive contracting play a major role to achieve supply chain integration. This path is largely reflecting what most previous authors have been arguing on this matter. However, besides this bilateral path of interdependent co-development towards supply chain integration, for certain construction sectors, unilateral paths towards supply chain integration must not be disregarded, such as in housing, where contractors teaming up with specialists and suppliers, or groups of specialists, or suppliers who also install pre-installed houses through supply chain integration business models. And from the client's perspective, certain powerful clients develop their own supply chains without being dependent on existing supplying parties in the construction market. These differentiated views on development paths towards supply chain integration, including differentiated view on construction clients and construction sectors will lead to a more balanced and realistic view on and discussion about what supply chain integration in construction actually is and could be, and the role of new procurement initiatives in order to achieve the supply chain integration.

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The search for causes of dissatisfaction in the building industry

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Abstract

Rework and failure in the Dutch building industry can lead to dissatisfaction for involved parties. Literature and former research gives insight into preventing these problems based on a linear relation between cause and consequence. However, it can be questioned whether dissatisfaction for involved parties is caused by one aspect or one party only. This article describes a part of an ongoing research conducted to get insight into dissatisfaction. The article describes arbitration as a data source and describes a method to get insight into dissatisfaction using this data source. Temporary results show while parties have a legitimate claim for money or repair in a conflict it is often not a party being right *or* wrong but rather being right *and* wrong. A possible way to deal with multiple causes for problems is by acting and interacting of involved parties.

1. Introduction

In the Netherlands a substantial part of the building industry's turnover is lost due to deficiencies, rework and failure which can all lead to dissatisfaction for involved parties. In literature several authors search for relations between these problems in the building industry and what it might have caused. A linear relation is presumed between cause and consequence. Fenn et al. [1] state in their search for causes of disputes: "if it is possible to identify causal factors the construction industry's actors might seek to avoid or forestall them". Kumaraswamy and Chan [2] focus on productivity to develop counter-delay strategies. In their research lower productivity is identified as a key contributor to (or a root cause of) delays.

Although this former research gives insight into preventing problems based on a causal relation, it can be questioned whether dissatisfaction can be caused by one aspect or one party only. Possibly dissatisfaction is caused by a multiple-dimensional phenomenon existing of multiple causes which amplify each other. Handling this more dimensional phenomenon is possible through acting and interacting. Literature shows this organizing through continuously construction of meaning of parties involved. The organization is not static and not fixed on beforehand but is continuously constructed through interaction. For example, Bouwen *[3]* states, based on social construct reasoning, that by focussing on the relational quality, new possibilities for conversations among parties can be created and new ways of intervening can be invented. Also according to Hosking and Morley [4] "Relational processes are considered to be instrumental to connect inputs to achieve outcomes. In contrast, when the relationship between person and context is seen as one of mutual creation, the concept of process is very different. This is because outputs cannot be reduced to the inputs of either actor or context, but rather are seen as the emergent product of their interrelation."

The underlying research, in the Netherlands, is conducted to get insight into dissatisfaction in the building industry. The starting point of this research is the parties being actors in their process of demanding and supplying a construction product. Parties create their dissatisfaction during the building process. Although of course, it is not their goal, parties are unaware their acting and interacting leads to dissatisfaction. In this research the focus is to find causes for dissatisfaction and their inter-correlation whereby the acting and interacting of parties might be of large influence.

This article first describes the use and usefulness of arbitration jurisprudence as an information source. The exploring of arbitration data should give insight in the form of data possible to obtain from the information source and should confirm the researcher being not prejudiced when extracting information form the arbitration jurisprudence.

The article secondly describes a method to get insight into dissatisfaction in the Dutch construction industry using the arbitration jurisprudence. Using the method two different procedures are distinguished in discovering dissatisfaction based on the arbitration information source. The first procedure (A) focuses on finding correlations between arbitration variables which are not visible on beforehand. The second procedure (B) starts with presumptions of correlations between variables obtained form the arbitration information source. The presumptions are derived from literature or defined as a hypothesis. Of both the procedures an example is described and temporary results are shown.

2. Arbitration

The underlying research started as a survey research to get insight into dissatisfaction by using the knowledge of project participants. By means of interviews the insight was to be obtained. However, there was some scepticism whether accurate and sufficient information would be available. This scepticism is confirmed by the experience of Barber et al. [5]. Barber et al. describe the measuring of costs of quality failures and the hurdles they experienced when collecting data: "Records kept by the construction company were inadequate for even just an analysis of failures, costs placed against rework were incomplete, it proved extremely difficult to obtain a reliable view of type and quantity of failures and relating costs from interviewees' perceptions, and filling in standard forms by company personnel proved also unsuccessful because they were already filling in too many forms and because the personnel did not have the necessary details." An information source which is easier to access and which contains more detailed information than a survey is possibly found in arbitration jurisprudence. The information source used in the underlying research is the jurisprudence of the Court of Arbitration for the building industry in the Netherlands [6]. The jurisprudence of Court of Arbitration for the building industry in the Netherlands is public available in the form of arbitration judgements.

Not all disputes originating from dissatisfaction will end up in arbitration. Possibly dissatisfaction in the construction industry is not completely represented by dissatisfaction in arbitration disputes. However, arbitration judgements show dissatisfaction in a drastic form, the intensity of dissatisfaction is that high parties conclude they themselves cannot settle the conflict and need a third party to settle the conflict, furthermore, they dare to take the risk of losing the dispute and pay additional costs. In Figure 1 the Dutch building industry as a set of transactions is shown. The transactions in which one party is, or both parties are, dissatisfied is shown as a subset. At this moment, it is not proven parties to be indeed dissatisfied when using arbitration; this is assumed and needs validation. Furthermore, possibly the arbitration cases are not entirely a subset of dissatisfaction but do have an overlap with the transactions in which one or both parties are satisfied in the Dutch building industry. This might be the case, for example, when both parties start an arbitration procedure entirely based on parties' policy.

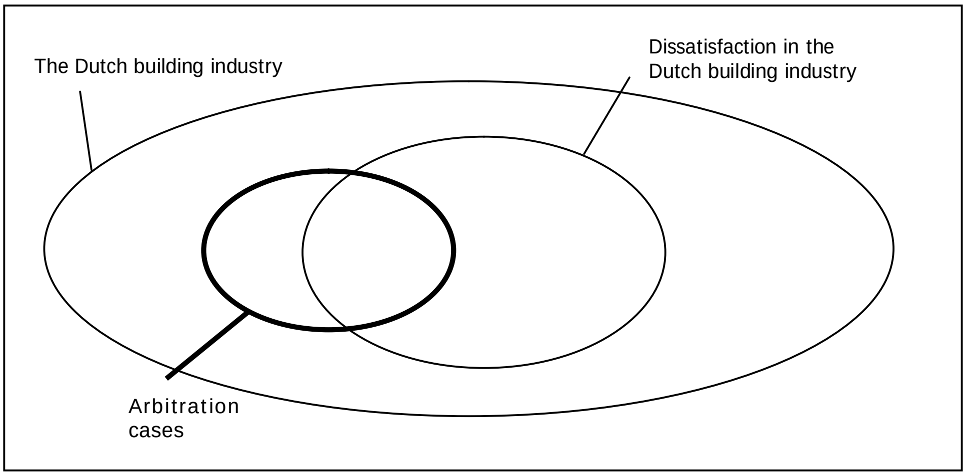

Figure 1. Arbitration cases in the Dutch construction industry

A phase in the underlying research is focussed on exploring arbitration data. In this phase two steps are distinguished. The first step in the phase establishes whether dissatisfaction exists in the Dutch building industry and how the dissatisfaction is expressed in the arbitration judgements. The second step in the phase establishes whether the researcher is able to obtain information sufficiently independent of prejudice. The first step shows dissatisfaction, often of both parties, in the form of claims made by each of the parties. The arbitration judgements describe in general the following procedure. A party initiates the arbitration procedure with a demand existing of multiple claims. In the first phase of the procedure both parties have the opportunity to present claims and answer the claims made by the other party. Claims often exist of the claim made for an amount of money or rework/repair. Next, the arbitrator pronounces judgement existing of judging the party getting its' claim rewarded or rejected and a motivation of this pronounced judgement. The second step is based on the former findings and exists of asking cooperative readers to extract information from the arbitration judgements by answering questions. The co-readers were asked to read five arbitration cases and to note answers to the following questions: (a) "what does each of the parties claim from the other party?", (b) "is this claim rewarded by the arbitrator?", and (c) "how does the arbitrator motivate his pronounced judgement?". The answers of the co-readers were mutually compared and were compared to the answers noted by the researcher.

Results of the reading of arbitration cases by co-readers show mainly consistency in the answers of co-readers and the researcher. There is no significant incorrectness in reading the arbitration cases and answering the described questions (a) "what does each of the parties claim from the other party?", and (c) "how does the arbitrator motivate his pronounced judgement?". All readers note similar answers. However, answers to the question (b) "is the claim rewarded by the arbitrator?" were not consistent. Occasionally (but consistent throughout the five cases) claims were rewarded according to a reader and not rewarded according to another reader.

Based on the insight obtained form the reading of arbitration judgements the arbitration information shows two types of variables. The first type of variables (1) can have different values within an arbitration case; each variable is dependent on each of the parties' claims. These variables are shown in Table 1 in the left column. The second type of variables (2) can have different values within the sample, however, are constant within a single arbitration case; each variable is dependent on the building project. These variables are shown in Table 1 in the right column.

Table 1. Different variables in arbitration cases

Variables which differ within an arbitration case, and differ within the sample and population	Variables which are constant in an arbitration case, and differ within the sample and population
Claim of each party (demanding or supplying) in words	Initially claiming party
Claim of each party (demanding or supplying) as an amount of money	Does a party appeal against an arbitrator's decision?
Claim of each party (demanding or supplying) as a relative percentage of what is totally claimed by both parties	Contract price
Reward by the arbitrator, motivated in words	Type of contract
Reward by the arbitrator as an amount of money	Type of demanding party
Reward by the arbitrator as a relative percentage of what is totally rewarded by the arbitrator	Type of supplying party
Resulting dissatisfaction as an amount of money	Type of sector
Resulting dissatisfaction as a relative percentage of the total remaining dissatisfaction	Number of arbitrators
	Type of arbitrator
	Dates of contract/ delivery/ start of arbitration/ oral application/ verdict

Possibly, based on these variables the acting and interacting of parties can be observed. Furthermore, possibly dissatisfaction can be deduced form these variables. The following method is based on finding correlations between the variables as observed.

3. The method

The method used in the underlying research exists of two procedures. The first procedure (A), starts with a empty mind, empty of presumptions of dissatisfaction manifesting itself in a certain way. The goal of this procedure is to find correlations between variables which are not visible on beforehand. This procedure is based on statistical analysis. The second procedure (B), starts with presumptions of correlations between variables. The presumptions are derived from literature or defined as a hypothesis. An example of the latter procedure is the presumption the demanding party not being able to get its claim rewarded; and ends up being still the most dissatisfied compared with the supplying party. Van Bladel [7]. Describes two different kinds of parties based on Galanter's difference between 'one-shotters' and 'repeat-players'. According to van Bladel private demanding parties are 'one-shotters' because they use arbitration only once and supplying parties are 'repeat-players' because they more often use arbitration. Subsequent a correlation must exist between the claiming party (demanding or supplying) and the claim and reward. Of both procedures an example of temporary results is shown in the next paragraph.

4. Temporary results

Based on the two described procedures the following temporary results can be found. A first temporary result of discovering the claiming by parties and the rewarding by the arbitrator shows a variation of different claims. The different claims are shown in Table 2. A percentage is given of how often a claim is made for what reason.

A second emerging result is the fact that a party can be right and wrong by claiming for compensation. An example of this situation is as follows: a demanding party (client) is dissatisfied with a minor non-conformity. The supplying party (contractor) denies the claim of the demanding party for rework. Acting upon this denial the demanding party refuses to pay a term. Acting upon the non payment of the term the supplying party stops the execution. Who is right and who is wrong? The demanding party has the right to complain about a minor non-conformity, however, does not have the right to refuse paying. On the other hand the supplying party does not have the right to deny the non-conformity, however, does have a rightful claim for the payment of the term. Table 2 shows based on the different claims the number of claims the party is right according to the arbitrator, the number of claims the party is wrong, the number of claims the judgement is not explicit, and the number of claims the party is both right and wrong.

Table 2. Claims of the parties and rewarding by the arbitrator

Claim of each party (demanding or supplying party)	N Party is right	N Party is wrong	N Party is both right and wrong	N Unknown	N total	% of total
Pay non-judicial costs	1	3	4	3	11	3,1%
Pay expert's advice	3	5	6		14	3,9%
Pay invoices	1	1	2		4	1,1%
Pay rework		4	2		6	1,7%
Pay additional work	17	8	11		36	10,1%
Pay arbitration process	15	27		1	43	12,0%
Pay interest	3	12	22	4	41	11,5%
Pay damage	5	11	3	1	20	5,6%
(Payment remaining)	13	4	7	4	28	7,8%
Action by the other party	2	5		2	9	2,5%
Repair/rework object	15	20	10		45	12,6%
Non-compliance penalty	1	5	2		8	2,2%
Non payment of costs of arbitration	9	34			43	12,0%
(Non payment remaining)	3				3	0,8%
Non accessibility of other party		3		22	25	7,0%
Remaining reasons	11	9	1	1	22	6,1%
Total	99	151	70	38	358	100%

A third temporary results emerging form the arbitration data is the motivation of the arbitrator why a party is right, why wrong, or why a party is both right and wrong. By distinguishing two levels the insight into the arbitrators' motivation is expanded. The first level shows why a party is (partly) right or (partly) wrong. Table 3 shows the arbitrators motivation why a party is right and gets its claim rewarded (level 1). Table 4 show the arbitrators motivation why a party is wrong and does not gets its claim rewarded (level 1). A second level shows a further in-depth motivation by the arbitrator (Table 5 and Table 6). For example, a party claims payment of additional costs. The arbitrator motivates the party being wrong and having no rightful claim for money (level 1), because there is no additional work at all (level 2). Another example is a party claiming payment of arbitration process costs. The arbitrator motivates the party being wrong and having no rightful claim for money (level 1), because the party is wrong for 50% in the arbitration process, resulting in each party having to pay its own costs (level 2).

Table 3. Rewarding of the claim (level 1)

Claim is rewarded because (level 1)	N	% of total
The use of arbitration	44	12,3%
Rightful claim payment of expert	4	1,1%
Rightful claim payment of additional work	21	5,9%
Rightful claim remaining	15	4,2%
Rightful claim payment of interest	24	6,7%
Rightful claim payment of damage	5	1,4%
Rightful claim PART of payment remaining	34	9,5%
Rightful claim PART of costs procedure	14	3,9%
Rightful claim of PART of repair/rework	9	2,5%
Rightful claim of repair/rework	15	4,2%
Does not have to pay amount of money	12	3,4%
Remaining reasons	13	3,6%
Unknown	148	41,3%
Total	358	100%

Table 4. NOT rewarding of the claim (level 1)

Claim is NOT rewarded because (level 1)	N	% of total
Non-compliance penalty not rewarded	5	1,4%
The use of arbitration	40	11,2%
No rightful claim payment of expert	3	0,8%
No rightful claim payment of additional work	3	0,8%
(No rightful claim remaining)	88	24,6%
No rightful claim payment of interest	8	2,2%
No rightful claim payment of damage	3	0,8%
(No rightful claim PART of payment remaining)	37	10,3%
(No rightful claim PART of payment of interest)	24	6,7%
(No rightful claim PART of repair/rework remaining)	9	2,5%
No rightful claim repair/rework of non-conformance	18	5,0%
No rightful claim repair/rework remaining	2	0,6%
Unknown	103	28,8%
Remaining reasons	15	4,2%
Total	358	100%

Table 5. Rewarding of the claim (level 2)

Claim is rewarded because (level 2)	N	% of total
To decide not possible	8	2,2%
Building of house conform governmental approval	2	0,6%
Justly incurring PART of costs	6	1,7%
Cut down costs by supplier	3	0,8%
Admitted by counter party	11	3,1%
Outstanding invoices	3	0,8%
No repair/rework at all	2	0,6%
Justly incurring of costs	7	2,0%
Party did get insufficient information	3	0,8%
Repair/rework third party if supplier lacks activity	3	0,8%
Reasonably decided	5	1,4%
Partly just claim of additional work	2	0,6%
Justly claim of hidden deficiency	5	1,4%
justly claim of additional work	9	2,5%
Delivered materials insufficient	4	1,1%
Has to be accepted as completed	5	1,4%
Not attended to in case	5	1,4%
Demanding party did not agree with additional work	2	0,6%
Supplier is willing to repair/rework	2	0,6%
Delivery has been done	2	0,6%
Remaining reasons	21	5,9%
Party is right in arbitration process	3	0,8%
Party is PARTLY right in arbitration process	21	5,9%
Party remains (fin.) balance	26	7,3%
Parties agree	3	0,8%
Claim is matter of procedure	26	7,3%
Substitutional claim and primary combined attended to	2	0,6%
Counter party is lacking activity	2	0,6%
Invoice is made payable	2	0,6%
Execution of work is insufficient	11	3,1%
Reward for devaluation	2	0,6%
Unknown	150	41.9%
Total	358	100%

Table 6. NOT rewarding of the claim (level 2)

Claim is NOT rewarded because (level 2)	N	% of total
No reason for reward	2	0,6%
Responsibility other party not definite	2	0,6%
Number of days and amounts of money not correct	3	0,8%
Number of days not correct	6	1,7%
Call in of guarantee rightful	2	0,6%
Amount(s) of money not correct	13	3,6%
To decide not possible	5	1,4%
Non-conformance not perceived	3	0,8%
Claimed amount too high	12	3,4%
Insufficient evidence	11	3,1%
Claimed is more than non-conformances	3	0,8%
Non-conformance is insufficiently shown	2	0,6%
No worth in claiming	2	0,6%
Insufficient deliverance of evidence	2	0,6%
Repair/rework instead of money rewarded	2	0,6%
No non-conformance at all	6	1,7%
No additional work at all	3	0,8%
No hidden deficiencies at all	2	0,6%
Choice of materials or method	6	1,7%
Costs are arbitration costs	2	0,6%
Costs incurred for self-interest	5	1,4%
Costs of repair/rework calculated	2	0,6%
Not attended to in case	5	1,4%
Supplier should have know as an expert	3	0,8%
Supplier is willing to repair/rework	2	0,6%
Causal relation not confirmed	3	0,8%
Party is partly wrong	55	15,4%
Party is wrong	5	1,4%
No remaining (fin.) balance for party	10	2,8%
Claim is matter of procedure	26	7,3%
Situation is not cause for deficiency	2	0,6%
Counter party is not lacking activity	2	0,6%
Remaining reasons	38	10,6%
Unknown	105	29,3%
Total	358	100%

Using 20 arbitration cases a fourth result confirms the presumption as made by van Bladel. The demanding and supplying party claim more or less equally at the start of the arbitration process based. This is shown in Figure 2 using relative percentages[1].

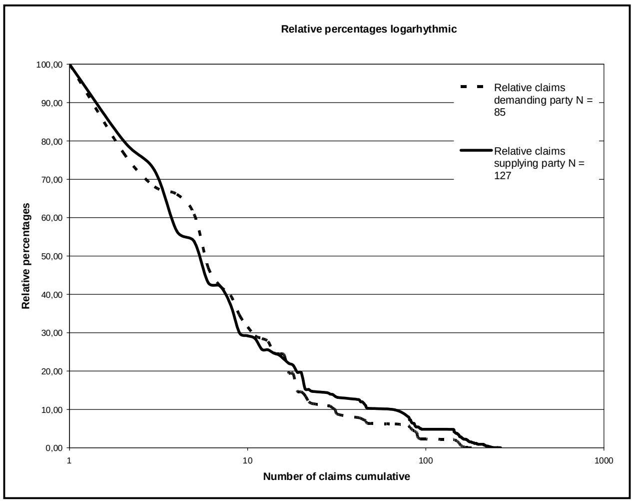

Figure 2. *B3.1 Relative claims*

The demanding party does get significant less rewarded compared to the supplying party Figure 3.

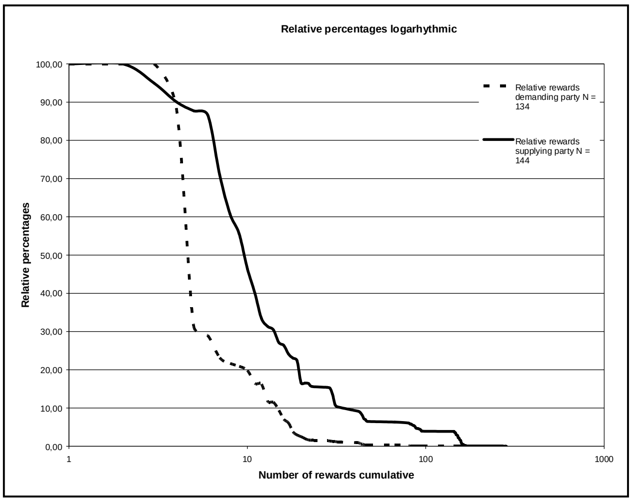

Figure 3. *B3.1 Relative claims*

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[1] The relative percentages are derived from the amounts of money claimed/rewarded/resulting by a party relative to the total amount of money claimed/rewarded/resulting. Claims that do not have a financial component are not included.

Finally, what is claimed minus what is awarded results in the demanding party ending up with the biggest remaining claim Figure 4.

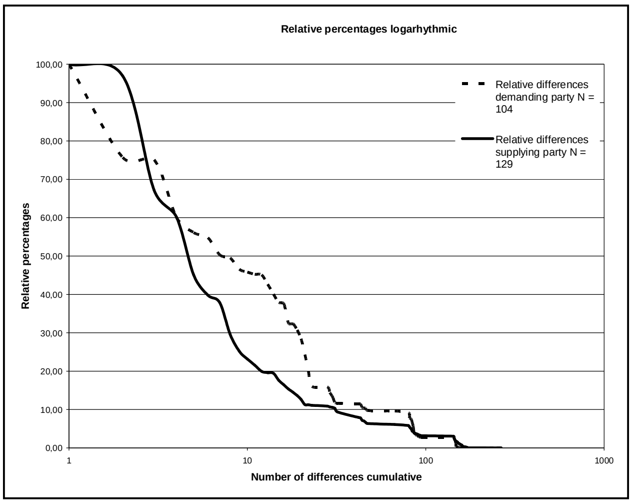

Figure 4. B 3.3 Relative resulting claim

Fenn et al. [1] used a survey to compare the occurrence of disputes in the construction industry versus the industry of chemical processing. They did find a correlation between the type of contract and the occurrence of disputes. In this research the sample of arbitration cases appeared too small to find variation in types of contract. Increasing of the number of arbitration cases in the sample might reveal results.

5. Discussion and conclusions

The basic research question 'does dissatisfaction exist within the Dutch building industry?' is confirmed using arbitration cases as a data source. The assumption that in all cases leading to arbitration one party is or both parties are dissatisfied is not contradicted. Therefore, arbitration cases will give insight into dissatisfaction.

Distinguishing demanding and supplying parties is useful. The presumption that the demanding party is the most dissatisfied party in arbitration can be confirmed Figure 2 through Figure 4.

Conflicts exist while both parties have a legitimate claim for money or repairs. Temporary results show that parties can both be right and wrong (Table 2). Opposite of what parties go for in arbitration, results show that often it is not a matter of being right *or* wrong but being right *and* wrong. In 99 of 358 claims the party is completely right, in 151 of 358 claims the party is completely wrong, in 70 of 358 claims the party is both right and wrong, and in 38 of 358 claims the arbitrator does not pronounce judgement. Parties start the arbitration process claiming money or rework from the other party. Whilst doing this they explicitly reject the claims of the other party. This at least indicates lack of interaction between the demanding and supplying party. In this way the claims can become an autonomous process which continuously is strengthened by lack of interaction.

The blaming of the other party being the cause of problems is earlier identified by Chan and Kumaraswamy *[8]*. In their research they asked clients, consultants, and contractors to identify the main factors causing project delay. Although agreeing on the major causes the clients and consultants blamed the contractors to have a lack of experience in planning and site monitoring, and the contractors blamed the consultants (architects/engineers) to have a lack of design experience. [2] suggest that differences in perceptions as to causes of delays by different groups and the blaming for delays to other groups may discourage a search for the root causes of the delays. The origin of such biases may be traced to group conditioning, as well as to the present adversarial nature of the contractual systems, including the clashes, blame allocation and defence postures induced by the not uncommon 'extension of time' claims and associated costs in construction contracts.

In earlier research dissatisfaction was observed as an linear relation (difference) between the construction object as expected and later actually experienced [9-11]. This linear relation was also earlier defined by Aplebaum et al. [12]. Aplebaum et al (2000) define dissatisfaction in the light of medical service: Satisfaction or dissatisfaction with a service occurs when there is a “disconfirmation” between expectations an actual performance. Satisfaction occurs when actual performance exceeds expectations; dissatisfaction occurs when the patient’s experience with a medical service falls below expectations. However, dissatisfaction is not only dependent of the linear difference between expected and experienced, possibly being dissatisfied is more dimensional. Both the acting and interacting of parties influence dissatisfaction. To what extent and in what way needs further research.

In the underlying research the two procedures are further used to discover dissatisfaction. The arbitration data might give insight into results as found in other research, for example, [13] and [14].

Can we find a trace that suggests that a particular party in a particular construction context is predisposed and that legal or arbitration actions are infected by these predispositions rather than be based on being dissatisfied solely with the building product? [13]

Can we find some evidence that contractors plan claims at tender stage and sometimes during the course of a project? [14] Rooke et al. also “found evidence that strategy (of anticipation/planning on/of claims) varies from company to company, project to project and even in some companies, from individual to individual" [14]

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Changing value networks, money flows and investment targets

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Abstract

Building construction and infrastructure investments share of GDP depends on the structure of society. The basic assumption is that construction's role gets smaller in developed society. Yet, recent developments have shown that in the case of non-residential construction the level of advancement of a society is not as important a factor as the pace of change of the industrial and commercial base. In housing production, on the other hand, the basic assumption has proven correct. Since the year 2000 the European Union member states have invested more in renovation of housing than in new building. The structure, operations and value networks of building construction are changing.

The study describes how the volume and content of money flows change as investment in new building construction and infrastructure are replaced by investment in maintenance and renovation that maintains usability. The entire process from the clients to the implementers is going to change.

The presentation is based on a Licentiate thesis accepted at Tampere University of Technology in 2001 in Finland [1].

Keywords: Construction, Building Contracting, Material and Product Industry, Building Costs, Input-output Analysis, Income Distribution, Investment Expenditure

1. The Money Flows of Construction - an Input-Output Analysis

1.1 Introduction

The research problem is to link together construction volume, content, contracting and use of construction products. Related surveys are made on the national-economic level. So the goal of the study is to develop a national-economic level market analysing system which allows surveying construction as a whole and different sectors and contracting individually within the same framework.

The analysing system is to cover both new building construction and civil engineering and also renovation of built environment. In addition to quantitative changes in construction, the system must be capable of analysing the impact of technological changes within construction sub-sectors on the demand for both contracting and the construction products industry. The construction products industry is industry that produces the materials and components used on construction sites. Foreign trade in construction products is the importation and exportation of the same products.

1.2 Selection of Research Method

The structure, production and development of the national economy are monitored by the internationally agreed national-economic accounting system. Its key task is to calculate the gross domestic product (GDP). The GDP includes only the end products of various sectors. End products are products that are either consumed, added to capital or exported during the year of observation. Intermediate products are used to make end products. The value-added of a sector is arrived at by deducting the value of raw materials, semi-finished products and services bought from other sectors. The GDP is the sum of the value-addeds of all sectors.

The input-output statistics related to the accounting depict the relations between construction and other sectors. Input-output statistics are a form of so-called double-entry accounting of supply and its end uses. The supply table shows the production of goods and services by various sectors as well as their imports. The consumption table shows the products used by sectors as intermediate or end products or exported. The columns of the input-output table comprise the intermediate-product inputs purchased from other sectors and used own basic inputs by sectors. The rows of the table display the outputs of sectors divided into demand for intermediate-products by other sectors and demand for end-products by households, enterprises and the public sector, as well as investments and exports.

The basic inputs of the input-output tables are wage costs, employer's social security contributions, production taxes and subsidies, fixed capital outlays and operating surplus. Intermediate-product inputs consist of imported goods and goods and services purchased from other sectors including VAT, production taxes and product subsidies. The input structure indicates the need of the basic and intermediate inputs used by a sector.

1.3 The Advantages of Input-Output Analysis

The input-output method allows analysing inter-sector relations on the national-economic level. Use of the inverse matrix allows converting a sector's input structure into an overall input structure that reveals, in addition to the use of basic inputs by a sector, also the basic inputs from other sectors used to manufacture intermediate products.

The input-output method is suited for this project which intends to examine the relationships between the sectors involved in construction as construction volumes and the internal structure change. Input-output analysis provides the research a framework which links the value of the output of a sector to its content and construction to the national economy. The compatibility of the method selected by the project with official statistics broadens the perspectives on the study.

The key idea of this study is to treat construction as an entity made up several different markets. That is why the input structures of building components are determined instead of those of building construction and civil engineering. Overall basic input structures are calculated for building components using the inverse matrix in order to determine money flows. The impact of the internal structure and volume of construction are analysed based on the market shares of building components. Building components can also be combined into entities smaller than building construction and civil engineering such as typical contracting fields, construction product industry sub-sectors and building types.

2.1 Solution

The input data of the study consist of the results of several construction economics related cost studies dealing, for example, with units costs of structures and construction cost indices. The key concern in the adaptation of input data has been to break construction down into components of similar input structures (input coefficients, chart 1), to establish these input structures, and to determine their market shares.

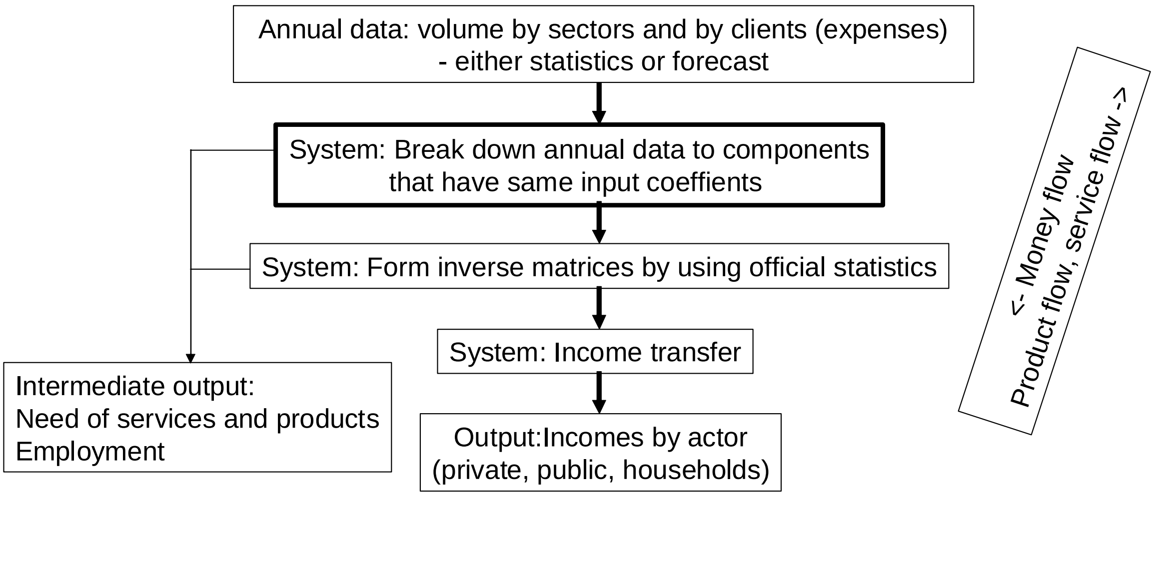

Chart 1. Inputs, outputs and structure of model.

The micro-units of building construction are 26 building components and those of civil engineering 10 contracting fields, which were selected mainly on the basis of the use of intermediate products and degree of prefabrication.

Using statistical data as input data allows analysing the impact of domestic demand on various sectors annually. The results are best suited for annual assessment of sector development or comparison of sectors. The method is too rough for product-specific analyses since market shares of building products based on example sites do not yield quite accurate market shares for all construction products and, consequently, their accurate annual demand.

When alternative forecast futures are used instead of statistical data, the development of sectors over the strategic term can be examined based on alternative development scenarios. The results of this kind of analysis are very useful in strategic decision making. As the case study 1 shows growing share of renovation can be attractive as business area.

System can also be applied to individual project to show the money flows. For example via results can be analysed how one big public project effects regionally.

2.2 Case studies

Case 1: Impact of construction boom, new construction slump, and changed regional structure of Finland on the demand for building products

Changes in the demand for construction products can be viewed from several angles. The focus may be the markets of companies operating in Finland – both domestic and international construction markets – or domestic demand for imported construction products and domestic deliveries of the Finnish products industry.

The following equation yields the demand for construction products companies operating in Finland:

+ deliveries to domestic markets
+ imports to international markets
= total demand for domestic (Finnish) construction products industry

The demand by domestic construction, again, can be derived from the equation below:

+deliveries to domestic markets
+ construction product imports
= domestic (Finnish) demand for construction products

Changes due to construction activity (chart 2) and the resulting changes in demand for services have also been calculated to serve as reference figures.

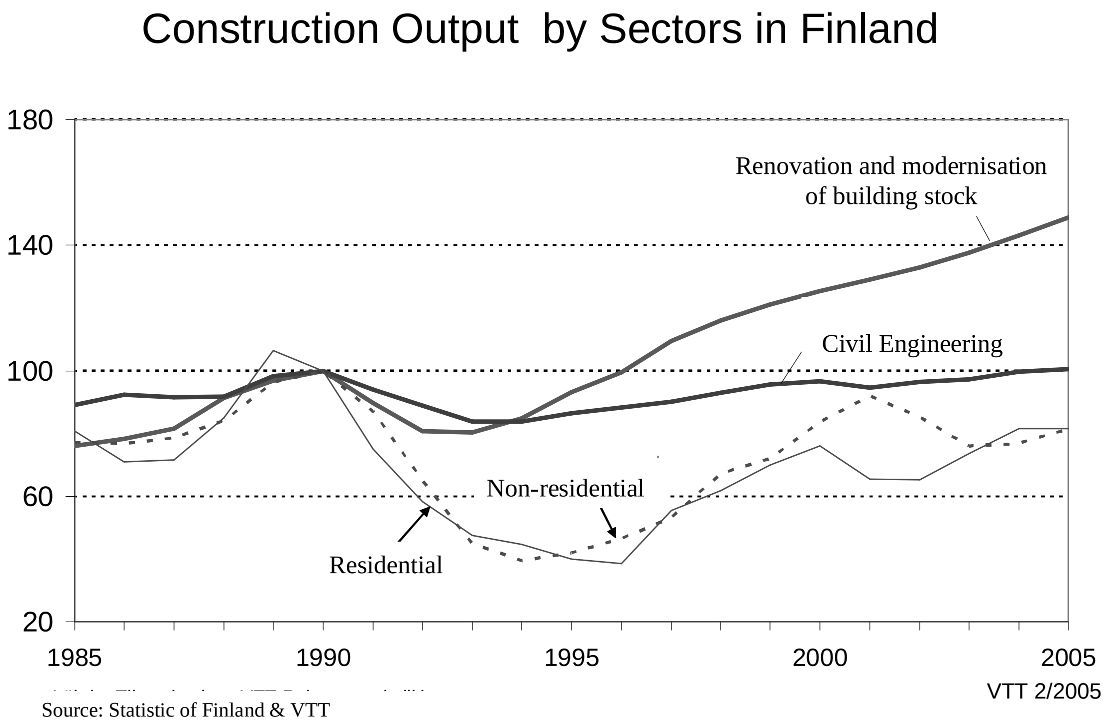

Chart 2. Volume of construction sectors in Finland.

The analysis showed that the construction products industry rode out the slump in demand for construction in the early 1990s better than construction proper. The non-metallic mineral industry is the industrial sector most tightly connected to domestic new construction which is why demand for its products fell more than in other branches. The metal industry that supplies the construction sector was least affected by the recession and was able to profit from the emphasis on renovation in building construction as well as exports.

Case 2: Revenue from construction

Construction brings revenue to several sectors and parties. The recipients can be determined by tracing the flow of money through different phases of the process all the way to those who produced the basic inputs. Money tied in basic inputs may accrue to an economic unit either directly as primary income or through income transfers. Income transfers are effected by taxation, and their share of primary income is determined by tax scales.

The primary income of construction-sector companies, as well as those of other sectors, consists of interest and operating surplus, part of which accrues to the public sector via taxation. Interest and operating surplus are subject to corporation taxes.

Households earn wage income, of which the pension insurance contribution, social security contribution and income tax are deducted and transferred to the public sector.

Official input-output calculations omit taxes. When the scope is widened to include sector clients, the value-added tax included in the sale price paid by dwelling buyers and the construction products purchased by independent builders enters into the picture. The buyers of new dwellings also pay a capital transfer tax in connection with the sale.

The revenue of the state and municipalities consists of taxes in the form of income transfers, other product taxes, social security and pension contributions by employers and employees, income and corporation taxes, and value-added and capital transfer taxes paid by households. The revenue of the public sector is reduced by the product subsidies it pays.

A third of the money used for construction ends up in the coffers of the public sector as tax revenue and social security contributions. If the value-added and asset transfer taxes connected to new building construction are factored in, the public sector's share of the revenue is significant. Household's share of the revenue is one quarter independent of the sector of construction. As an example there is outcome that finally gets the money from residential construction (chart 3).

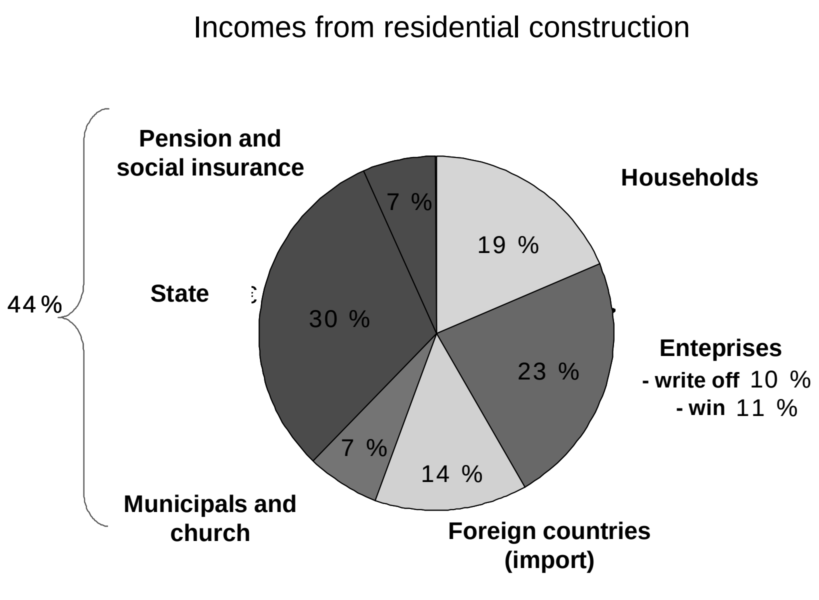

Chart 3. The outcome from input-output analysis of money flow in residential construction. The target is apartment in multifamily house, built by contractor [2]. Doesn't include site value.

3. Conclusions

The study describes how the volume and content of money flows change as investment in new building construction and infrastructure are replaced by investment in maintenance and renovation that maintains usability. The entire process from the clients to the implementers is going to change.

The basic assumption is that construction's role gets smaller in developed society. Yet, recent developments have shown that in the case of non-residential construction the level of advancement of a society is not as important a factor as the pace of change of the industrial and commercial base. In housing production, on the other hand, the basic assumption has proven correct. Since the year 2000 the European Union member states have invested more in renovation of housing than in new building. The structure, operations and value networks of building construction are changing.

The most essential variable is the amount of money invested in building construction. Whether the money is used to make an investment or to maintain a structure or building has little significance, for instance, as concerns the need of labour. This is central since our attitude toward construction is strongly affected by the "investments as share of GDP" variable which projects an image of a "declining industry".

Renovation is tied to place and local activity, but yet more closely linked to international markets than new building. New building uses local, heavy materials. Renovation largely involves products typically made by multinational giants. Renovation consists of small one-off projects that demand special skills of companies and workers. The roles learned in new construction do not serve implementation of renovation projects – they are driven by totally different parties.

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The Development of a Contractual Framework for Disaster Reconstruction

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Abstract

Disaster reconstruction management requires a different response to ordinary construction. One of the key factors to consider is the development of a fast and efficient contractual framework, or procurement system, for rebuilding following a disaster event. The objective of this paper is to explore the most efficient construction framework for reconstruction following such an event. The methodology for this research consists assessing different procurement options commonly in use for current effectiveness and then using this data to suggest the most suitable framework for use both locally in New Zealand and internationally for any given disaster event. The results will show how the current common procurement frameworks in use can assist with post-disaster reconstruction.

Keywords: Contractual frameworks, procurement, reconstruction, disaster, New Zealand

1. Introduction

Following a disaster, one of the requirements for reconstruction in the establishment of a comprehensive procurement framework for reconstruction. Without this, reconstruction and new development will be carried out on an ad-hoc basis with little regard for the needs of the society needing reconstruction. Current normal procurement mechanisms used in the construction industry need to be assessed for their suitability to deliver the best economic outcome in the event of a disaster. It is likely that without a comprehensive reconstruction procurement framework, rapid reconstruction will be significantly hampered. This research examines current common procurement types to assess their suitability for reconstruction following a disaster. Particular focus is made on the question of which is the best procurement option for this reconstruction.

2. Procurement Systems for Disaster Reconstruction

There have been changes in the forms of contract and other types of project relationships used in some sectors of construction in recent years [1], and these may be more suitable for reconstruction projects than traditional contracts. Procurement strategies such as traditional, design-build, partnering and alliancing can be judged against, amongst other things, time, cost, quality, industry familiarity, communication and management. Procurement systems are the organisational structure adopted by the client for the implementation of the project process and eventual operation of the project [2]. Procurement can be seen as a strategy designed to satisfy the client's development needs [3]. For disasters, the client is likely to be the government of the country undergoing disaster reconstruction. They will require guidance on the most useful strategy for reconstruction. The common purpose for all the procurement systems and the inherent part of a procurement system is to achieve the clients' objectives [4]. In an emergency situation reconstruction is required rapidly, and this should be at the forefront of the client's objectives. Cheung [5] suggests procurement is critical as it determines the overall framework embracing the structure of responsibilities and authority for participants within the building process. In all projects, but particularly in a crisis situation, clear structures need to be determined and responsibilities and authority for rebuild established.

Initially all projects were procured by using the traditional procurement system and even today a large number of projects are carried out by using the same procurement system Cheung [5]. Recent changes in the construction industry such as changes in the type of client and development of construction techniques have produced differentiation within construction processes and changes in organisational structures to satisfy a variety of clients' objectives [4]. This has led to the development of variety of procurement systems. Both Sanvido & Konchar [6] and Walker [7] comment on the relationships of the parties to the project. As Walker [7] points out, '…for the purpose of accomplishing a construction project an organisation can be said to be the pattern of interrelationships, authority and responsibility that is established between the contributors to achieve the construction clients' objective'. Hence the key to the management of construction project is the way in which the contributors are organised to use their skills effectively. Effective use of skills is an essential element to rebuilding after a disaster. Where large loss of life occurs, skills are lost and it is the need for the procurement system used to recognize the skills shortage and respond to it.

Commonly used procurement systems can be categorised as either traditional, integrated or management [4]. The traditional system is where the project process is separate and sequential in nature (construction follows design and tender) and is the oldest form of construction procurement [3]. An integrated system, as described by Al Khalil [8], is where single organisation is responsible for design and construction of the project and the involvement of the client is at a single point. Common examples of these procurement systems are design and build, built-operate-transfer (BOT), built-operate-own-transfer (BOOT), turnkey and package deal. The management approach is where an additional role of construction manager (CM) or project manager (PM) is added in the organisation to look after the project objectives. These systems as described by Walker & Hampson [9] are the combination of traditional system of procurement and integrated approach because in this kind of system a separate entity, often called project manager, acts in a management role and the project manager is responsible for all clients' objectives through one point of contact with the client. Few recently developed systems under this category are project alliancing and strategic partnering which are largely based on the ethics of the project participants [10].

In a disaster, the ability of a governing organization to quickly establish an adequate procurement system for rebuilding is crucial. For reconstruction following a disaster event it is hypothesized that the procurement framework needs to have the following:

- Short time for rebuilding
- Low cost
- Use of local material, labour and plant
- Well developed communication links between the parties
- Local industry familiarity with the framework
- Well developed relationships between the parties (including trust and respect between the parties)

The following sections assess the different common procurement options for their suitability against the above factors.

2.1 Usefulness of the Traditional Approach for Disaster Reconstruction

The traditional procurement system is known as the system with separated design and construction organisation. Walker and Hampson [9] describe this'… approach to procuring project involves discrete design development, tender, contract award and construction phases. Each phase is, in theory, separate and distinct.' In this system the client appoints a designer such as an architect or design engineer who fully designs the project and helps the client in selecting the contractor by inviting the tenders [11]. In this system the architect or designer acts as a team leader and has functional relationships with other project participants. Masterman [12] suggests that for the small or medium size projects where complexities and uncertainties are not high this form of procurement proves economical. Masterman [12] further points out that the organisation structure of this system is fragmented and sequential in nature and procurement participants are separated and have separate responsibilities. The fragmented nature of this system makes a complex network of communication. Shockley-Zalaback [13] suggest that effective communication is important for successful delivery of project as it has been linked to team effectiveness, the integration of work units across organisational levels, characteristics of effective supervision, job satisfaction and overall organisational effectiveness'.

McGeorge and Palmer [14] refer to the main disadvantage of this system as one which '…removes the contractor from the design development phase and thus much management and contractual information is lost'. The traditional system of procurement has a noted advantage over the other procurement systems as Masterman [12] suggested '…provided that the design has been fully developed and uncertainties eliminated before tenders are invited… proper competition is ensured…and the selection of bid that is more advantageous to the client will present little difficulties'.

In a disaster, the ability of a traditional framework to quickly respond to rebuild could be a disadvantage. If a short time for rebuilding is required then using the traditional system may be a disadvantage. As Wilkinson & Scofield [11] suggest the traditional system usually results in a longer time period for the whole construction project mainly because the design is often fully completed before tendering and construction. They further point out that usually the longer the time period, the higher the cost, hence the traditional system is often associated with higher costs [11]. A higher cost product would be a disadvantage is a disaster rebuild situation, as financial resources will already be stretched. However, with full design documentation at tender stage, the total cost of the project should be known which might introduce some clearer measure of reconstruction costs. The traditional system is associated with design by a design professional and a quality product. Administration of the project by a design professional usually means high quality as the design professional is often focused on quality. Care should be taken that, following a disaster, quality is not taken to mean importing expensive material at the expense of getting local infrastructure and material supply businesses functioning. The traditional system is a well understood, tried and tested procurement system making it attractive from a familiarity viewpoint. If the parties have worked together with the framework on previous projects then there is likely to be well-developed relationships between the parties. However, the fragmented and sequential nature of the systems tends to mean that communication becomes complex. This is s disadvantage when working in a crisis situation where clear and easily understood communication systems are required. On balance, the main impediments to this system for reconstruction following a disaster are the time, cost and communication factors. The main advantages for reconstruction following a disaster are familiarity with the system and receiving a quality product.

2.2 Usefulness of the Integrated Approach for Disaster Reconstruction

In an integrated procurement system, design and construction are integrated and became the responsibility of one organisation. The design and build is an arrangement where one contracting organisation takes sole responsibility for the design and construction of the client's project [12]. Design and build is the main member of the integrated system, other types include package deal, built-operate-transfer (BOT), built-operate-own-transfer (BOOT), novation and turnkey are also examples in the category. Cheung [5] describes the popularity of these systems in the construction industry '…these options become fashionable when more and more contracting organisations are armed with a design function. In fact, for those with financial capability, their service can be extended to build-operate-transfer.'. Masterman [12] suggests that design and build gained popularity because there was '…heavy demands upon the construction industry and shortage of construction resources, coupled with claims by contractors of greater efficiency and lower cost when using this method…" Wilkinson & Scofield [11] suggest that these systems are good for typical construction where standardised techniques and materials are to be used. This system proves useful only when the client's brief and detailed design are properly communicated to the organisation responsible for the construction [12]. Masterman [12] further points out that systems like BOT and BOOT are more common for infrastructural projects than buildings because the concession allows for toll or other payments to be made by end users to cover the cost of both procuring the facility and its operation. Smith et al, [15] describes that the BOT entity undertakes financing, design, and construction as well as operation and so the client is taking no direct cost risk other than the possibility that the facility does not meet its need or that the concession agreement is unsatisfactory. For design and build suitability in disaster reconstruction consideration should be given to the reduction of time and cost which is of significance when rapid rebuild is required and financial resources are limited. As design and construction are the overlapping activities, this can reduce the overall time of project completion. Design and build also permits the incorporation of constructability information during design, so following a disaster, local knowledge of material availability and other resources can be incorporated into the project. Concern is expressed in the use of design and build because of the lack of checks and balances leading to a lower quality [16]. Quality may not be such a priority in a crisis situation, as recovery needs are more likely to focus on time and cost. Mulvey [17] summarises that the design and build approach is especially successful in the case where the scope of project is clearly defined, the design is a standard, repetitive design, and the schedule is tight. In a disaster, design and build procurement could be suitable because of this short time and low cost focus. This coupled with a local contractor's likely knowledge of the local construction industry such as fast access to local material, labour and plant make it an attractive option. The design and build system has uncomplicated and therefore it is easy to establish well-developed communication links between the main parties, contractor and client. In many countries internationally, design and build also scores on local industry familiarity with the framework. The only caution to be noted is in the reputation of the design and build framework to be focused on repetitive, simple constructions and some concerns about the reliance on one company to be able to undertake all the work effectively – hence trust becomes a major factor.

2.3 Usefulness of the Management Approach for Disaster Reconstruction

The common characteristics of all management oriented procurement systems are that in these systems a person or organization is contracted to manage the design and construction. Masterman [12] suggests that these systems can more readily respond to the client's needs, especially accelerated commencement and completion. Walker [7] describes project management as a procurement framework where the project manager generally coordinates the design and oversees those responsible for the work packages. In the case of a pure project management arrangement the project manager has management authority for both design team and construction team. The project manager acts as the executor and is the only entity to interact directly with the client [7]. Whereas in the construction management system where the project manager is usually a contractor, the expectation is that construction expertise of the contractor is encouraged in the design. In this system construction manager is a consultant hired by the owner to oversee the project process on the behalf of owner. Walker and Hampson [9] state about this expertise that '… this build-ability or constructability advice is crucial to the development of design solutions that maintain value in terms of the quality of product as well as providing elegant solutions to production problems.'

Having a management tier in a project could be advantageous during disaster reconstruction as the sole focus of the project management or construction management organisation is management of the project. The skill of the managing organization is critical to its success, more so in a disaster scenario where quick and efficient decision making is required. Wilkinson and Scofield [11] discuss the advantages and disadvantages of the project management system. They suggest that when a project manager is employed, then the programme may be shortened due to the project manager using increased knowledge of project planning. By concentrating on management, the project manager can focus on reducing the overall time. This could be good for disaster reconstruction management. Where skilled local project managers can be used for managing reconstruction then the expectations of project success are high. As with design and build, the project manager or construction manager, using existing communication links between the parties would be able to facilitate rapid rebuild – especially if the project manager has a well developed sense of the local material, plant and labour situation. However, there is a need to check for local industry familiarity with the system and in particular the value of having another management tier in the project increasing the lines of communication between the parties.

2.4 Usefulness of the Partnering Approach for Disaster Reconstruction

Wilkinson and Scofield [11] suggest that partnering is not technically a procurement system, rather it is a framework which overlays any of the procurement frameworks in operation. Masterman [12] concurs, suggesting, 'Partnering does not supersede the process used by the procurement system chosen to implement the project but rather acts as a framework within which the selected system operates more beneficially'. The definition provided by Construction Industry Board [18] describes partnering as: '…a structured management approach to facilitate team working across contractual boundaries. Walker [7] asserts that it '…is based essentially upon team spirit. The interesting aspect of this simple model is that all three essential elements require trust, commitment, honesty, integrity, good communication skills and technologies between parties'. In partnering there are three essential features; mutual objectives, continuous improvement and problem resolution [19]. Mutual objectives are the objectives that establish for everyone that their interests are best served by concentrating on the overall success of the project [19]. The second aspect, continuous improvement, involves team and individual feeling safe in measuring performance to learn from their experiences. This requires openness and honesty hence trust and commitment are major issues for improvement. In continuous improvement- performance is measured and analysed to provide knowledge about how improvement can be achieved continuously. There must be a commitment to learn from experience and to apply this knowledge to improve performance [19]. The third aspect, problem resolution requires the resolution of problems with an escalation strategy to solve them at the lowest organisation level possible [19]. Partnering is a voluntary arrangement made between all of the project participants, has no legal standing and imposes no contractual obligations upon any of the parties [10]. But, as Egan [20] and Latham [21] discuss, the partnering approach can prove useful in that construction process and in improving construction practices. For disaster reconstruction, partnering may be a suitable option to overlay other frameworks. As a focus on relationships and trust are likely to be crucial in such a situation, partnering might provide a vehicle for reconstruction. If local companies in a reconstruction zone have an established long-term relationship, as a system based on trust requires, then using partnering might be viable. Internationally, familiarity with partnering concepts may still not be high, but could be quickly learnt, especially given the needs of the parties to face the common objective of rebuilding communities.

3. Conclusion

In this paper analysis has focused on the most suitable procurement systems for reconstruction following a disaster. The analysis has focused on some key factors such as time, cost, quality, industry familiarity, communication and management and how these factors change with different procurement systems and hence their usefulness for reconstruction. What is not in doubt is that following a disaster, one of the requirements for reconstruction in the establishment of a comprehensive procurement framework for reconstruction. How this is achieved depends upon how the various factors interplay and what requirements and facilities exist in the local communities. Concluding, it appears that all procurement systems have specific attributes useful for disaster reconstruction. It is the weightings of these attributes to specific circumstances that are more critical.

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Efficiency Improvement through Procurement Innovation in the New Zealand Construction Industry

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Key words: construction, procurement, innovation, collaboration, demonstration

Abstract

An initiative engaging clients and the construction industry supply chain has been established in New Zealand, to publicise the benefits and encourage wider adoption of procurement and project delivery innovations throughout the industry. Innovative projects have been engaged as 'demonstration projects' to increase the knowledge base in the industry and, to prove the business case for change, a set of industry key performance indicators is being established to measure the benefits of innovation. Research has been carried out to support the initiative, including analysis of the significance of the construction industry to the New Zealand economy and an investigation into the range of procurement approaches currently used in the industry, together with case studies of a range of relevant construction projects.

1. Introduction

The following paper describes an initiative that aims to facilitate efficiency improvements and a culture change in the New Zealand construction industry. The various activities associated with this initiative are described and the results obtained so far are discussed.

1.1 Characteristics of the construction industry in New Zealand

The construction industry in New Zealand is similar to the traditional industry of the UK, in terms of the roles of the various supply-chain members, the forms of contract used, the types of relationships that are formed and the levels of efficiency in delivering projects. Recent research commissioned by BRANZ (2003) shows that the New Zealand industry has a major influence on the national economy. Whilst the construction sector's direct contribution to GDP is only around 5%, a 10% improvement in construction efficiency will result in a 1% change in GDP due to multiplier effects and gains in related sectors. Despite the importance of an efficient construction industry to the economy, the government has not intervened to encourage efficiency improvement but sees the responsibility lying with industry.

New Zealand, like the UK, experiences a range of construction procurement approaches, from traditional lowest price, lump-sum, competitive tendering to target cost and alliancing arrangements. The small size of the construction industry in New Zealand has facilitated a greater proportion of cooperative relationships between the various stakeholders to construction projects, particularly in civil engineering. In some cases the cooperative relationships have been formalized in partnering arrangements, in other cases collaborations have been more ad hoc and have been the result of the involvement of enlightened individuals in particular projects. Research undertaken to support the innovation initiative described in this paper (Henderson and Le Masurier, 2005) has shown that traditional contractual relationships are by far the most commonly used in New Zealand construction, with almost three quarters of all construction in New Zealand undertaken using either traditional design-bid-build or traditional design and construct. The use of partnering is however well established in the industry and is used in some form in approximately a quarter of all construction projects, see Figure 1.

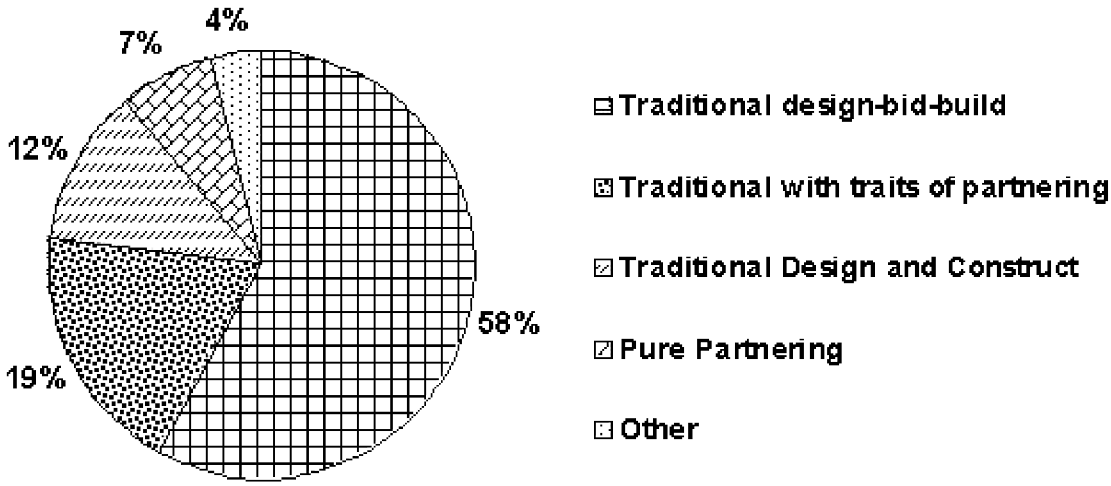

Figure 1: Proportions, by number of projects, of the most commonly used contractual relationships in the New Zealand construction industry (Henderson and Le Masurier, 2005)

1.2 Promoting innovation in construction project procurement and delivery

Recently the industry has experienced new levels of collaborative procurement arrangements, adopted by state owned enterprise client bodies as well as local and central government clients. A high level of interest in innovation was demonstrated at an industry conference on new forms of contract and procurement (Henriod and Le Masurier, 2002) and it was clear that there was a movement for change underway in parts of the industry. However, the efforts of a few enlightened clients and construction companies were dispersed, without a coordinated 'critical mass' of innovators or process for knowledge-sharing which could benefit the industry as a whole. It was therefore proposed that an industry owned initiative, similar to the UK's Construction Excellence, could help facilitate wider adoption of innovation, in particular innovation in procurement which was considered to offer the greatest potential for efficiency improvement.

2. Methodology

2.1 Steering Group

The Centre for Advanced Engineering (CAE) at University of Canterbury has a track record in facilitating expert groups and providing technology transfer and is recognised as an effective independent voice on engineering and technology-related matters. CAE fulfils the role of a knowledge broker and integrator across a number of engineering disciplines and since CAE already had an infrastructure programme it provided the ideal platform from which to establish a construction industry innovation initiative.

Key industry players involved in procurement innovation were invited to form a steering group to guide the initiative. The steering group has representatives from the whole construction supply chain including clients.

The initiative, known as Best Practice in Construction Procurement and Delivery, has a two-pronged approach: bottom-up focussed on processes and top-down focussed on policy, with the former leading and facilitating the latter.

2.2 Demonstration Projects

A fundamental part of the bottom-up initiative has been a programme of demonstration projects. Current projects using innovative procurement approaches (alliancing, partnering, integrated supply chains, etc) have been engaged in a peer review process. The purpose of the demonstration project process is to share experience and knowledge among the teams involved in the projects and to provide tangible evidence of the benefits derived as a result of the innovation. At the end of each project a case study is produced and seminars organized to showcase best practice and innovation to the wider industry.

The demonstration project process is based on that used by UK's Constructing Excellence, and follows the steps shown in Table 1. The peer review panel is made up of representatives from current and past demonstration projects, so stages 1-5 are confidential among the panel members. This process provides a 'safe' environment for panel members to share their knowledge and experience with like-minded people and ensure that the benefits are proven before going out to a wider audience at stage 6.

Stage	Process
Stage 1	Outline of the project innovations and anticipated benefits through meetings with the project team and submission of an application form.
Stage 2	Presentation by the project team to a peer review panel where the project is judged on its suitability for inclusion in the demonstration project programme.
Stage 3	Presentation and discussion by demonstrating projects to the peer review panel on the key performance indicators (KPIs) that will be used to demonstrate the tangible benefits specific to the innovation.
Stage 4	Collection and processing of KPI data and benchmarking with other demonstration projects.
Stage 5	Summarising and evaluating lessons learned and evidence of the benefits derived from the innovation in a final presentation to the peer reviewers.
Stage 6	Publication of a case history and dissemination to wider industry.

Table 1. Demonstration project process

2.3 Benchmarking

Whilst the demonstration projects use project-specific key performance indicators (KPIs) to benchmark internally, much of the evidence of the benefits from innovations is anecdotal. Without standard performance metrics to enable direct comparisons between projects and clear guidance on how to measure performance, it is difficult to prove the business case for innovation. Therefore, another underpinning element of the initiative has been to develop a national set of industry KPIs. A KPI steering group was set up to pursue this particular area and a set of KPIs was chosen based on what were considered to be the main areas for performance improvement in delivery of construction projects. The KPIs chosen are shown in Table 2 and use similar definitions to the UK's Constructing Excellence (2005) headline KPIs.

The project to establish and run a pilot trial of these KPIs has been carried out with funding from BRANZ and is nearing completion. The pilot results will be presented and the KPIs will be launched nationally at an industry conference in May 2005. Once established the national KPIs will provide a means of differentiating the better performing players from those who rely on traditional lowest price procurement processes and will allow industry players to measure their current performance and gain feedback on the potential for performance improvement. A process for regular industry benchmarking against the national KPIs will help to make the business case to industry and policy makers to do things differently, for the benefit of both individuals and the economy as a whole.

KPI

1. Customer Satisfaction – Product

2. Customer Satisfaction – Service

3. Quality – Defects

4. Accidents

5. Predictability – time

6. Predictability – cost

7. Turnover and Profits

Table 2. National Key Performance Indicators

3. Case study – Auckland Airport Runway

3.1 Introduction

Auckland Airport runway refurbishment works is one of the demonstration projects and the description below provides an example of the type of procurement innovation and resulting benefits that are being promoted through the initiative.

The Auckland airport runway was built in the 1960's and by 2000 was nearing the end of its service life. Whilst the runway has been lengthened to accommodate the requirements of larger aircraft, the concrete slabs under the original central section of the runway were not designed to carry the loads imposed by modern aircraft and needed replacing. The first stage of the refurbishment works required the conversion of the main taxiway into a temporary runway to allow closure of the main runway. The risk of disruption to operations and the thousands of people that travel through Auckland's airport daily was minimised by thorough planning for the refurbishment, considering an extensive array of potential operational impacts. Planning took two and a half years to complete. Risk in the delivery of the project was further minimised by selecting and partnering with contractors that demonstrated a customer focussed culture and a proven ability to perform well on such projects.

As the runway is critical to the core operation of the airport, the refurbishment works had to be carried out with minimal operational disruption and no delays. All specifications had to be met correctly first time, as passenger safety could not be compromised.

3.2 The Solution

Communication and detailed planning was the key to delivering this project successfully. An integrated delivery team was formed at the earliest stages of the project with the designers and contractors working together from the start. People working on the project at all levels participated actively in progress meetings. Clear and constant communication gave management the flexibility to optimise the work programme through faster decision making processes and allowed them to "design out problems". There were daily meetings to discuss past, present and future progress and to ensure all phases of the project were integrated with one another. Planning involved all those actually responsible for the site works together with feedback from extensive stakeholder consultations. A risk consultant was employed to perform a detailed risk analysis involving all stakeholders, as a result of which the project team was able to prepare contingency plans for a wide range of potential outcomes.

3.3 The Benefits

The benefits of the integrated delivery team were measured against the key performance areas of time, cost, quality and safety and the project was a success in all areas as follows:

• Time – construction was completed five days ahead of the tight 30-day planned schedule; this was the result of the extensive planning process and the use of backup plant to speed up construction

• Cost – prices were negotiated up-front with the contractors so there were very few variations and claims

• Client Satisfaction – the client was very satisfied with the end result and early completion was a bonus for the end users

• Work Continuity – there were no programme delays and no accidents.

4. Results

The Best Practice in Construction Procurement and Delivery initiative has developed steadily, from the 'bottom-up' over the past 2 years. Several of the larger construction and consulting companies and major clients in New Zealand have supported the initiative both financially and through the steering group. Five demonstration projects have been completed, covering a range of project types, scales and procurement approaches and several further demonstration projects are currently underway. All projects are demonstrating excellent levels of performance in the industry KPI areas. Progress on the initiative overall has been slow however, due to lack of resources. The initiative is beginning to make some headway now in the 'top-down' policy area. Once the national KPI project has produced the first round of results there will be an opportunity to demonstrate to policy makers in government the benefits that can be obtained from improved procurement processes. Although applications for government funding to support the initiative have been unsuccessful previously, it is hoped that the government will see the benefit to the national economy resulting from a more efficient construction industry and support this initiative, in collaboration with industry. A lesson to learn from the experience to date is that establishing an industry-owned initiative is hard work with limited resources and no prime funding. This is in contrast to the initiatives in UK and Australia which have received significant public funding from the start, the former now moving towards greater industry ownership and less public funding. A barrier encountered, due to the lack of capacity of industry to cope with the current workload, has been getting the key people to spend their time in meetings and in the peer review process. The irony is that during the buoyant times when innovation could be thriving, companies do not have the spare resources to consider and implement new ideas. However, the number of new projects using collaborative relationships in the industry is steadily increasing.

5. Conclusions

From a historical perspective, it has been proposed that innovation in construction procurement in New Zealand has occurred organically through the involvement of various enlightened individuals. Though the industry in New Zealand is small and new ideas and ways of working can spread relatively easily, traditional approaches to procurement are dominant in many sectors, with associated inefficiencies often in evidence. In order for innovation to spread more rapidly, a coordinated approach was needed and the paper has described the various aspect of an initiative to facilitate innovation in construction procurement. The initiative was established in collaboration with industry and used as its foundation the evidence available from existing best practice projects. A process has been described by which the learning from such projects is captured. The KPI results from a national benchmarking initiative will further underpin the business case for procurement innovation and help towards achieving the overall objective: improving the efficiency and culture in New Zealand construction.

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Targeting Constraints and Improving Performance in Singapore Construction

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Abstract

The construction industries in many countries are besieged with constraints such as low productivity, lack of cost control, low level of standardisation, low quality control, lack of training and the inability to meet schedule. The main constraints in Singapore's construction industry need to be identified, so that appropriate actions may be taken to improve the industry. The objectives of this research are (1) to identify issues that cause constraints and challenges to companies, and affect their ability to improve their business activities; and (2) to investigate whether different players in the construction industry, viz. clients, consultants, main contractors, specialist contractors, subcontractors and suppliers, face the same problems. An industry wide survey revealed that all the 41 issues identified in the study significantly affect them. The industry has, collectively, also identified top main constraints to be 'client focus on lowest price at tender stage' and the 'narrow profit margins in construction business activities'. It is recommended that solutions be found to overcome many constraints in the construction industry, especially those relating to benchmarking performance, corporate development, and improving relationships and profitability.

Keywords: challenges, construction industry development, problems, constraints

1. Introduction

The main constraints in Singapore's construction industry are low productivity, heavy reliance on foreign workers, multi-layered subcontracting, and the industry's poor safety record [1]. The industry's productivity growth rate is also very low: it recorded negative productivity growth rates from 1995 onwards. The productivity problems are attributed to factors including a heavy reliance on an unskilled foreign workforce. Another influencing factor is the multi-layered subcontracting system adopted in the industry where over 91% of registered firms in 1998 employed less than 50 people. A third factor is the segregation of design from construction owing to the predominance of the traditional system of procurement. The lack of involvement of contractors in the design process often leads to less buildability, maintainability and safety, as well as reworks and increased costs.

The objectives of this research are (1) to identify issues that cause constraints and challenges to companies, and affect their ability to improve their business activities; and (2) to investigate whether different players in the construction industry, viz. clients, consultants, main contractors, specialist contractors, subcontractors and suppliers, face the same constraints. The importance of this paper is that the results provide some insights into the actions that should be taken in improving the construction industry.

2. Possible constraints and challenges

A literature search was undertaken to identify the issues that cause problems and challenges to companies operating in the construction industry. For brevity, only some of these issues are discussed below. In many countries, the main constraint that the construction industry faces is low productivity. In the USA, construction productivity has been on the decline since the 1980s [2]. As a consequence, the cost of construction has increased by 50% over the inflation rate [3].

A world-wide phenomenon in the construction industry relates to an 'obsession' with the lowest cost. Many studies through the years have pointed out that tender price or initial capital cost dominate the final contractor selection decision, and less attention paid to other contractors' attributes [4, 5]. Other constraints faced by the construction industry include lack of cost control, low level of standardisation, low quality control, lack of training and the inability to meet schedule [6].

From the literature review and collective experience of the authors, 41 possible issues that are likely to cause constraints and challenges to companies, and affect their ability to improve their business activities were identified. There is a need to ascertain to what extent these constraints affect Singapore's construction industry and from there, suggestions to overcome the constraints may be given.

3. Research Methodology

A questionnaire was designed, to find out to what extent the issues identified were significant. The first part of the questionnaire comprised introductory questions for data classification. The second part of the questionnaire consists of statements regarding the possible constraints and challenges that prevent companies from achieving significant improvements in their business activities (see Appendix 1). Respondents were asked to indicate the effect of these constraints on a seven-point Likert scale, where 1 represented ‘strongly affect company’s ability’, 4 indicated ‘neutral’, and 7 stood for ‘no effect at all’.

In this study, there were six population frames comprising: clients, consultants, main contractors, specialist contractors, subcontractors and suppliers. The different groups were studied because they occupy different positions in the construction chain, and have different power and influence in the development process. They are also subjected to different sets of problems and challenges.

The samples were selected randomly from published directories and websites. The survey package comprised a cover letter, the questionnaire, and a pre-stamped and self-addressed envelope. A pilot study was conducted prior to the full-scale industry-wide survey.

4. Results

A total of 1815 questionnaires were sent out and 200 (response rate of 11%) usable returned questionnaires were received. The characteristics of the respondents are summarised in Table 1.

Table 1 Summary of characteristics of respondents

Characteristics	Number	Percentage (%)
DESIGNATION		
Upper management	86	43%
Middle management	72	36%
Professionals	23	11.5%
Others	19	9.5%
TOTAL	200	100
CONSTRUCTION EXPERIENCE		
≤ 6 year	32	16%
7-15 years	62	31%
> 15 years	106	53%
SIZE OF CONSULTANTS		
Professional staff	Median= 5 staff	
Technical staff	Median= 12 staff	
SIZE OF GENERAL CONTRACTORS		
Paid up capital ≤ US$3 million	32	76%
Paid up capital > US$3 million	10	24%

From Table 1, it can be concluded that the survey captured the interest of people who play major roles in the construction industry. They were also holding senior positions in their firms, and had practised in the construction industry for a long period of time.

Mean ratings were calculated from the feedback received (see Table 2). Statistical t-tests of the mean were carried out to check the entire population's (construction industry participants in general) likely response to the issues raised in the questionnaire, based on the sample's ratings. The results showed that all 41 issues significantly affect the companies' ability to improve their business activities (see Table 2, at $p \leq 0.05$)

Besides the overall mean, the mean ratings were also calculated for the six different categories of respondents. Analysis of variance (ANOVA) was carried out to ascertain whether different construction industry participants have different views about the issues presented, at 0.05 significance level. The ANOVA revealed that seven issues were not rated in the same manner (see Table 2). Even though the different groups have different objectives, this small number of differences shows that for the majority of the issues the different groups of respondents had perceived the constraints and challenges in a similar manner.

The issues that were not rated in the same manner could be divided into two groups. In the first group, clients and consultants felt that the issues affected them, but main contractors, specialist contractors, subcontractors and suppliers (collectively known as contractors) felt that these issues affected them to a lesser extent. The issues that fall in this group are as follows: high number of unskilled foreign workers employed by contractors and sub-contractors (H24); low level of use of IT in your company (H32); lack of standardised system of classifying and sharing of information to allow increased usage of IT (H33); and high start-up cost of IT implementation in the company (H34).

In the second group, contractors felt that the issues prevented them from achieving business improvements, but clients and consultants were affected to a lesser extent. These issues are as follows: client focuses on lowest price at tender stage (H16); current standard conditions of contracts do not create positive working relationships on projects (H9); and allowing too many companies to tender for any single job or project (H14).

The above shows that different respondents in the construction chain are more concerned about their immediate needs, and have thus focused on problems that affect them directly. This meant that concerted effort to improve the construction industry may be difficult, as parties are still unwilling to adopt holistic approach to solving problems.

5. Discussion

5.1 Benchmarking performance

Six constraints were classified under the 'benchmarking performance' heading. From the ratings, the third most serious issue in the construction industry is the relative ease for poor performing companies to enter the market (H4). Currently, unskilled workers, and poor performing contractors and consultants are allowed to operate in the construction industry. The fact that poor performers are in the industry is because clients allowed them to be in there, when they emphasise low cost, at the expense of quality.

In the absence of benchmarks, clients would not have proper standards to judge the quality of these players and may not know if they will be getting value for money when engaging them. Another constraint faced is the relative ease for poor performing companies to enter the market. The low barrier of entry would mean that incompetent firms continue to operate in the industry. To overcome lack of benchmarking problems in the construction industry, it is recommended that the Building and Control Authority starts a performance measurement system.

5.2 Relationship

The survey revealed that there is a lack of collaborative culture in contracting. Organisations are reluctant to develop long-term business relationships. Clients have the tendency to call fresh tenders for every new project, and subject contractors whom they have prior business relationships with, to competitive tenders. Hence, there is no incentive to develop long-term business relationships. It was also found that the current standard conditions of contract do not create positive working relationships on projects. Adversarial relationships are known to affect overall productivity negatively [7].

To transfer risks to contractors, clients are introducing modifications to standard conditions of contract to reduce their risks. This makes it difficult for contractors to improve their business activities. The modifications may increase the adversarial relationships which are already present in many projects. C21 has therefore recommended that there should be minimum modification to the standard contracts, and this addresses the worry of the respondents about this matter.

5.3 Profitability

The two most significant constraints in the construction industry relate to monetary matters: client focuses on lowest price at tender stage (H16) and narrow profit margins in construction business activities (H17). Tender evaluation that focuses on lowest tender would mean that other contractors' attributes such as quality delivery, are overlooked. The narrow profit margins arise because of fierce competition from many tenderers. The successful contractor may thus not have the resources to deliver the results that would satisfy the client and end users.

From the result, it is not encouraging to know that construction firms find it difficult to make a profit. While tendering gives the client the advantage of competitive pricing and also forces contractors to control cost and maintain a profitable position [8], the client's quest for the lowest price caused profit margins to drop to unrealistic levels, leading to a compromise in project quality.

5.4 Working conditions

Poor working condition is another serious constraint in the construction industry. Arditi and Mochtar [6] found that in the USA, it is becoming more difficult to employ qualified labour. Foreign workers from developing countries, looking for a source of income, would have to be hired. The dirty-dangerous-dreadful (3-D) image of the construction industry can to some extent be improved by using more prefabrication and nurturing a pool of local workers in selected areas by suitable promotion and training programmes [1].

5.5 Productivity and quality

Construction sector's low productivity, as compared to other sectors of the economy, is well known. Arditi and Mochtar [6] found that it is necessary for designers to minimise on-site activities, by increasing the use of prefabricated and precast components. This also leads to easier management of quality and project control. Buildable designs can be achieved through constructability reviews [9] and design reviews [10]. Recommendations to increase construction productivity include hiring skilled workers, setting a minimum buildability level, having incentive schemes to encourage prefabrication and encouraging modular dimensions [1].

The results also show problems with low quality, arising mainly due to the use of unskilled labour. The presence of unskilled and untrained workers in Singapore is not unique. In the USA, unskilled labour abounds, and proper trained labour is becoming scarce, leading to a crisis in the quality of the work performed [6]. Substandard works and frequent reworks arise due to the use of semi-skilled workers [11]. These quality deviations may account for up to 12.4% of total project costs [12]. The government's tightening of entry of unskilled foreign workers together with levying a high tax on these unskilled workers will force contractors to employed skilled workers.

5.6 Innovation and IT

Studies have shown that R&D is important to improve business activities. However, there is still a low level of investment that companies give to R&D. In particular, Singapore companies may still have the mindset that R&D activities and funding should come from the government.

The results show constraints relating to low IT usage (H32), the lack of standard system of classifying and sharing information (H33) and high start-up cost (H34). Many firms in the construction industry use IT for simple word processing and spread sheet functions, and do not exploit its other potential such as e-commerce, Internet and emails. The use of IT is important, especially in projects of high complexity, in order to ensure that there is proper control system, with accurate and timely input data [13].

5.7 Corporate development

The respondents felt that they do not have the ability of develop long-term business strategies (H38), and there is a lack of objective measures that can allow the monitoring of progress within the business (H39). Finally, there is a lack of strong leadership from major clients to improve performance of the construction industry (H40). There is a need to return to the fundamental question 'why should the industry improve its performance?'. The reason should not be because 'the government says so' or 'because it is good for the economy'. Consultants, contractors and suppliers must be put in a situation that they want to improve their performance because it is demanded by the clients, i.e. it makes commercial sense to improve. Therefore, clients should take the lead to demand for better performance from construction industry players.

Due to Singapore's small construction market, respondents are aware of the need to undertake more overseas projects. The survey shows that what the players need are access to reliable information about the international construction markets (H35), and helping them to compete in overseas markets (H36) in order to clinch more overseas projects. Besides encouraging firms to form consortia to compete overseas [1], there is a need for private firms to take the plunge and rely less on the Singapore government to help them thrive overseas.

6. Conclusion

The research revealed that the construction industry in Singapore faces many constraints. These issues cause challenges to companies' ability to improve their business activities. The three most significant issues are: client focuses on lowest price at tender stage; narrow profit margins in construction business activities; and relative ease for poor performing companies to enter the market.

While Singapore already has a construction blue print in the form of C21 report [1], the recommendations in C21 do not address all the constraints uncovered in this study. The implication of this finding is that there is still some way to go, to solve the other problems in the construction industry. Singapore may need another blue print to complement C21, in order to bring the construction industry to a world class standard. However, while the Singapore government can provide some assistance, ultimate, the initiative, drive and direct action must come from the firms themselves.

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Appendix: Possible problems and challenges

Ref	**Problems and challenges**
	BENCHMARKING PERFORMANCE
H1	Lack of ranking for *contractors* according to their performance and quality of work.
H2	Lack of ranking for *material suppliers and component manufacturers* according to their performance and quality of work.
H3	Lack of ranking for *professional advisers* according to their performance and quality of work.
H4	It is relatively easy for poor performing companies to enter the market.
H5	Lack of licensing system for contractors.
H6	Lack of formal code of conduct for contractors, developers and some professionals in industry.
	RELATIONSHIP
H7	Lack of effective involvement of the client during the design process.
H8	Lack of effective involvement of the client during the construction process.
H9	The reluctance of organisations involved in construction projects to develop long-term business relationships.
H10	Current standard conditions of contracts do not create positive working relationships on projects.
H11	Modifications to standard conditions of contract by clients and developers.
H12	Lack of cooperation and understanding among professionals.
	PROFITABILITY
H14	Allowing too many companies to tender for any single job or project.
H15	Extensive use of competitive tendering in construction contracts.
H16	Client focuses on lowest price at tender stage.
H17	Narrow profit margins in construction business activities.
H18	Domination of large/ complex projects by foreign firms.
	WORKING CONDITIONS
H19	Image of the construction industry as being dirty, demanding and dangerous.
H20	Difficulty of providing a safe and decent working environment for workers involved in construction activities.
H21	Difficulty of attracting and retaining Singaporean workers.
	PRODUCTIVITY & QUALITY
H13	Moves to encourage increased use of DB contracts.

Ref	**Problems and challenges**
H22	Productivity of the construction industry compares unfavourably with the rest of the economy.
H23	Current building designs do not allow for high buildability.
H24	The high number of unskilled foreign workers employed by contractors and sub-contractors.
H25	Number of foreign workers (skilled and unskilled) employed by the contractors and sub-contractors.
H26	High level of tolerance towards defects in construction.
H27	Low level of satisfaction of the company's clients and customers.
H28	Low quality of graduates joining your company.
	INNOVATION & IT
H29	Lack of a national body to spearhead R&D effort in industry.
H30	Low level of investment and priority the company gives to R&D.
H31	Lack of incentives to encourage creativity and innovation in construction.
H32	Low level of use of IT in your company.
H33	Lack of standardised system of classifying and sharing of information to allow increased usage of IT.
H34	High start-up cost of IT implementation in the company.
	CORPORATE DEVELOPMENT
H38	Ability of construction companies to develop a long-term business strategy.
H39	Lack of objective measures that can allow the monitoring of progress within the business.
H40	Lack of strong leadership from major clients to improve performance of the construction industry.
H41	Lack of impetus for change in construction.
H35	Access to reliable information about the international construction markets.
H36	Ability of your company to compete in the overseas markets.
H37	Potential of construction companies to be world-class.

Table 2 Statistical analysis of the problems

No.*	Overall Mean				Means of individual groups of respondents						ANOVA	
	All respondents N= 200	Rank	t-value	Sig.	General Contractor N= 42	Sub-contractor N= 26	Specialist Contractor N= 33	Supplier N= 24	Consultant N= 48	Client N= 27	Sig.	F-value
H16	2.14	1	-17.999	0.000	1.825	1.8	1.813	2.043	2.295	3.2	0	4.26
H17	2.45	2	-15.222	0.000	2.5	2.375	2.219	2	2.558	3	0.19	1.51
H4	2.46	3	-16.513	0.000	2.357	2.654	2.576	2.435	2.455	2.308	0.92	0.29
H14	2.49	4	-14.658	0.000	1.952	2.692	2.273	2.652	2.652	3.038	0.04	2.45
H15	2.62	5	-13.309	0.000	2.4	2.48	2.594	2.478	2.659	3.2	0.35	1.12
H21	2.7	6	-11.618	0.000	2.714	3.154	2.636	2.739	2.467			
H40	2.72	7	-12.974	0.000	2.625	2.542	2.781	2.609	2.721	3.08	0.76	0.52
H24	2.79	8	-10.845	0.000	3.05	2.64	3.25	3.174	2.432	2.2	0.04	2.45
H31	2.83	9	-12.607	0.000	2.333	3.077	3.182	3	2.756	2.923	0.07	2.11
H6	2.85	10	-11.988	0.000	3.143	2.269	2.576	3.217	2.822	3	0.07	2.12
H38	2.88	11	-12.428	0.000	2.85	3.167	2.75	2.652	2.805	3.12	0.61	0.72
H10	2.9	12	-10.803	0.000	2.714	2.28	2.848	2.522	3.311	3.52	0.01	3.37
H22	2.91	13	-11.429	0.000	3.024	2.958	2.727	3.087	2.87	2.808	0.91	0.31
H12	2.93	14	-11.016	0.000	2.69	2.923	2.758	3.13	3.152	3	0.61	0.73
H19	3.05	15	-8.439	0.000	2.846	3.125	3.063	3.045	3.4	2.64	0.44	0.96
H18	3.07	16	-7.738	0.000	2.821	3.04	2.656	3.304	3.295	3.44	0.36	1.11
H11	3.12	17	-9.645	0.000	2.952	2.833	3.063	3.087	3.182	3.68	0.21	1.45
H25	3.13	18	-8.822	0.000	3.167	2.731	3.364	3.652	3.152	2.654	0.09	1.94
H41	3.14	19	-9.617	0.000	3.095	3.48	3.03	3.609	3.043	2.808	0.18	1.54
H9	3.15	20	-8.261	0.000	3.048	2.92	3.031	3.273	3.279	3.36	0.83	0.43
H39	3.2	21	-9.076	0.000	3.275	3.25	3.031	2.913	3.326	3.28	0.75	0.53
H2	3.22	22	-8.389	0.000	3.286	3.28	3.394	2.913	3.261	3	0.74	0.55
H3	3.24	23	-8.224	0.000	3.214	3.192	3.424	3.087	3.217	3.308	0.95	0.22
H1	3.25	24	-7.799	0.000	3.143	3.08	3.545	3.174	3.261	3.269	0.8	0.46
H30	3.27	25	-7.479	0.000	3.333	3.28	3.545	3.435	3.065	3.038	0.62	0.71
H34	3.27	26	-7.272	0.000	3.381	3.231	3.061	4.304	3.022	2.923	0.01	3.52

No.*	Overall Mean				Means of individual groups of respondents						ANOVA	
	All respondents N= 200	Rank	t-value	Sig.	General Contractor N= 42	Sub-contractor N= 26	Specialist Contractor N= 33	Supplier N= 24	Consultant N= 48	Client N= 27	Sig.	F-value
H7	3.28	27	-7.187	0.000	3.119	3.28	3.061	3.348	3.364	3.64	0.66	0.65
H23	3.3	28	-8.042	0.000	3.262	3.115	3.727	3.522	3.222	2.923	0.15	1.65
H37	3.33	29	-6.42	0.000	3.2	3.5	3.25	3	3.279	3.84	0.4	1.04
H29	3.4	30	-5.332	0.000	3.05	4.083	3.194	3.478	3.578	3.167	0.12	1.76
H20	3.43	31	-5.46	0.000	3.095	3.731	3.531	3.636	3.4			
H8	3.43	32	-6.032	0.000	3.262	3.4	3.29	3.739	3.511	3.48	0.77	0.5
H26	3.46	33	-4.794	0.000	3.381	3.84	3.303	3.87	3.478	3.04	0.38	1.07
H5	3.47	34	-5.162	0.000	3.667	3.44	3.455	3.522	3.4	3.308	0.94	0.26
H33	3.47	35	-5.776	0.000	3.429	3.76	3.394	4.217	3.333	2.923	0.01	3.06
H35	3.5	36	-4.287	0.000	3.025	4.25	3.323	3.565	3.622			
H13	3.5	37	-4.436	0.000	3.049	3.52	3.813	4.043	3.435	3.44	0.18	1.54
H28	3.53	38	-4.781	0.000	3.714	3.615	3.394	3.565	3.4	3.48	0.9	0.32
H27	3.53	39	-4.519	0.000	3.548	3.423	3.394	4	3.432			
H36	3.66	40	-2.838	0.01	3.55	3.8	3.656	3.304	3.864			
H32	3.67	41	-3.509	0.000	3.667	3.615	3.727	4.217	3.867	2.808	0.01	3.4

* The problem numbers correspond with those shown in the Appendix.

Effect of severe acute respiratory syndrome on the construction industry

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Abstract

The objectives of this research are: (1) To find out the preparedness level of the construction industry during the Severe Acute Respiratory Syndrome (SARS) outbreak in Singapore; (2) To assess the threat pose by SARS on the construction industry during the SARS outbreak in Singapore; (3) To evaluate the effectiveness of the anti SARS measures that were implemented in the construction industry; and (4) To recommend other possible effective measures that can be implemented in the future to guard against SARS. The research methodology employed in the study consisted of a questionnaire survey. Data were collected from contractors, consultants and clients. Results showed that the preparedness level of the construction industry was good and the precautionary measures implemented were effective. Recommendations on possible precautionary measures that can be adopted in the future to guard against SARS are provided to allow the construction industry to have better preparation for future SARS invasion.

Keywords: Severe Acute Respiratory Syndrome, precautionary measures, epidemic.

1. Introduction

Singapore was plagued by the severe acute respiratory syndrome (SARS) between March and May 2003. A total of 205 contracted SARS and 33 people died of it [1]. Singapore reported the fifth largest number of SARS cases after China, Hong Kong, Taiwan and Toronto. This unexpected epidemic outbreak wreaked havoc in Singapore, causing a direct impact of 2% drop in its gross domestic product (GDP) [2] and creating a greater uncertainty to the already dampened economy.

Since there has not been any report on the effects of SARS on construction industry, it is not known whether SARS has posed a threat to the construction industry and how prepared the construction industry was towards SARS. Even if the preparedness level is sufficient, it is not known if the precautionary measures that they have taken to prevent the spread of SARS were effective. There may be more effective measures, which have not been explored. Therefore, it is vital to investigate the impact of SARS on the construction industry, the preparedness level of the construction companies and the effectiveness of the current precautionary measures implemented as well as the potential precautionary measures that may be feasible.

The objectives of this research are: (1) To find out the preparedness level of the construction industry on SARS during the SARS outbreak in Singapore; (2) To assess the threat pose by SARS on the construction industry during the SARS outbreak in Singapore; (3) To evaluate the effectiveness of the anti SARS measures that have been implemented in the construction industry; and (4) To recommend other possible effective measures that can be implemented in the future to guard against SARS.

2. Research method

A sample survey was used to gather the necessary information required for this study. In order to obtain an overall view of the effect of SARS on construction industry, four groups of target respondents were selected for the study. They included the contractors, consultants, clients and other construction-related services participants (e.g. facilities management).

The contractors were selected through personal contacts and from the Building Construction Authority (BCA) Contractors Registry website using the purposive sampling technique. In the case of the non-contractors (consultants, clients and other construction-related participants), they were selected through personal contacts and from Singapore Yellow Pages 2003 using purposive sampling method. A total of 120 survey forms were sent to the various participants to gather the required data for analysis. These comprised 60 contractors, and 20 each of consultants and clients. The distribution pattern of the sample ensured that equal attention was paid to both the contractors and non-contractors. Questionnaires were sent by post or emailed to the firms, and returned via the same routes. The survey was conducted from September to October 2003, and respondents were given one month to complete the questionnaires.

The questionnaire design consisted of four sections to facilitate data collection. Section A asked general questions to determine the characteristics of the respondents. Section B asked respondents about the level of preparedness of various companies in construction industry. On a scale of 1 (which represents poor) to 5 (which represents outstanding), the respondents were requested to indicate the preparedness level of his company during the SARS out break in Singapore. In the second part of this section, the respondents were requested to rate the impact of SARS as a threat to construction industry, on a 5-point scale where 1= totally agree and 5= totally disagree. Section C provided a list of precautionary measures implemented in construction industry during SARS outbreak and respondents were asked to indicate their effectiveness on a 5-point scale where 1= totally not effective and 5= very effective. In Section

D, the respondents had to rate new precautionary measures to guard against SARS in construction industry in future on a 5-point effectiveness scale.

3. Data Sample Characteristics

120 survey questionnaires were posted or emailed to the various participants in the construction industry. A total of 63 forms were returned, giving an overall response rate of 53%. Among these, 58 responses were usable. The profile of respondents is shown in Table 1. Contractors formed the majority of respondents.

Table 1 Characteristics of respondents and their firms

Respondents' characteristics	Frequency	Percentage*
Nature of firm (predominant)		
Design and consultancy	13	22.4
Construction	33	56.9
Client	12	20.7
Designation		
Top management	2	3.5
Middle management	22	37.9
Professionals and supervisors	34	58.6
Years in Industry		
Up to 5 years	23	39.7
6-10 years	17	29.3
11-15 years	7	12.1
16-20 years	5	8.6
> 20 years	6	10.3
Presence in Singapore during SARS outbreak		
Yes	58	100
No	0	0
Involved in projects during SARS outbreak		
Yes	58	100
No	0	0
Experience with Home Quarantine Order		
Yes	12	20.7
No	46	79.3
You or your staff contracting SARS		
Yes	1	1.7
No	57	98.3

* Rounding off error may have occurred.

The respondents were considered knowledgeable to respond to the survey. All of them were in Singapore and managing projects during the SARS outbreak. Their involvement in construction projects would allow them to have a clear account of the activities that happened in the construction sites during the SARS period and strengthened the reliability of their responses.

4. Results and Discussion

The one-sample t test was first used to test the four areas in concerned: whether the preparedness level is adequate, whether SARS is a threat to construction industry and whether the precautionary measures implemented or suggested for the future are effective.

4.1 Preparedness of construction industry for SARS

The one-sample t test is first conducted on the preparedness level of construction industry on SARS. The preparedness level of companies on SARS has a high mean value of 3.897 (out of 5.0), at $p = 0.000$. This infers that the preparedness level of the construction industry on SARS is well above an adequate level. However, this finding differs from Loosemore's [3] finding that many construction companies have a low state of crisis preparedness.

One of the reasons for such good preparation is the intervention of Government. As Leung and Ooi [4] explained, the Government has launched intensive public education and awareness campaigns nationwide via the media such as newspaper, television and radio stations to raise the public awareness about this new respiratory illness. In addition, with effect from 16 June 2003, the Ministry of Manpower (MOM) had required employers to ensure daily temperature-taking for all workers at construction worksites employing more than 25 workers and foreign worker dormitories. It has also introduced a series of precautionary measures to keep workplaces free from SARS [1]. Ministry of Health, on the other hand, has too disseminated critical information about the disease to all workplaces. With proper education on SARS through different distribution channels, employers know that they have a role to play in containing this modern epidemic. Hence, they will spare no effort in maintaining the highest level of vigilance against SARS by taking precautionary measures at the workplace to prevent any import or export of the disease and raise the construction industry preparedness level as a whole.

4.2 Impact of SARS on the Construction Industry

Respondents were requested to rate the impact of SARS on the construction industry on SARS (see Table 2). All the eight test variables have $p > 0.05$. It is concluded that SARS has not posed a negative impact on the volume of construction demand, work flow of construction sites, productivity and quality of construction works and finally, the morale, motivation and absenteeism of the workforce.

In addition to the economic repercussions from the Iraq war, the Asian economy is dealt a further blow with the outbreaks of SARS. As such, investment analysts and economists have slashed economic growth and prospects of Asian countries. Some have even described the SARS outbreak as the biggest crisis since the Asian Economic Crisis in 1998 [4]. Without a doubt, Singapore economy suffered as well. However, the respondents felt that SARS did not aggravate the already weak construction industry, which was already suffering negative growth before, during and after SARS outbreak.

Table 2 One-sample t Test on possibility of threats imposes by SARS.

SARS was a threat to company as:	**Mean**	**t**	**Rank**	***p* (1-tailed)**
The volume of the construction project to tender reduced	2.569	-2.916	4	0.998
The work flow on site and office was affected, causing delay in construction works	2.966	-0.231	2	0.591
The work flow on site and office was affected, causing cost increase in construction works	2.793	-1.369	3	0.912
The quality of the construction works reduced	2.052	-7.801	7	1.000
The productivity of the workforce reduced	2.793	-1.318	3	0.904
The morale of the company workforce reduced	2.397	-4.211	5	1.000
The motivation of the company workforce reduced	2.310	-5.019	6	1.000
The absenteeism of the company workforce increased	3.172	1.166	1	0.124

The reason for such finding could be because Singapore had kept a close watch on SARS and responded fast to counter and contain this epidemic disease. As commended by Dr Jody Lanard and Dr Peter Sandman, risk communication consultants in Princeton, New Jersey, “In terms of managing urgent health problems, Singapore was the master of this in the SARS crisis.” [5]. Furthermore, Singapore’s actions also alleviate public’s fear for SARS and even injected more confidence into investors doing business in Singapore. Singapore then Prime Minister Goh Chok Tong also praised Singaporeans for their ‘fearless effort’ to fight SARS and they should take pride in how they had impressed the investors and the rest of the world [6].

As a result, the main parties in construction industry, and the building developers, did not lose confidence in Singapore building economy too. The construction companies and investors went ahead with their planned schedules or projects on hand. Most of the employees also went to work as per normal. Hence, the demand did not fall, sentiments of the construction workforce were not affected significantly and the productivity and quality of the construction works remained satisfactory. On the whole, the construction industry has not been significantly affected by the SARS outbreak.

As the survey was conducted only a couple of months after SARS had hit Singapore, the full impact of the SARS outbreak on construction sector may not yet be felt. There may be delay effects of SARS outbreak on the construction industry.

4.3 Precautionary measures implemented

Respondents were asked to rate the effectiveness of the precautionary measures implemented in construction industry (Table 3). All the precautionary measures have $p = 0.000$. It is concluded that all the precautionary measures taken are effective.

Among the top four most effective precautionary measures, three of them are related to temperature-check. This finding is accordance with the current most effective method of early detection of suspected SARS cases acknowledged by Government [7]. The effectiveness of informing and educating employers and employees to help prevent the spread of SARS at the workplace is self-explanatory. Proper education of both employers and employees on the disease can certainly serve to allay fear, thwart misleading rumors and prevent panic among the workforce, as well as help foster better understanding of the disease [4].

The three least emphasized precautionary measures identified are: urge employers not to send staff for work assignments or training in SARS-affected countries, urge employers to temporarily hold back rotation of staff from Singapore to SARS-affected countries and vice versa and introduce a system to facilitate contact tracing.

Table 3 Results on effectiveness of precautionary measures implemented

Precautionary Measures implemented in construction industry	**Mean**	**t**	**Rank**	***p* (1-tailed)**
Inform and educate employers and employees to help prevent the spread of SARS at the workplace	4.138	15.917	3	0.000
Guard against the import of SARS through foreign workers who stay in Malaysia but commute to work in Singapore daily	3.931	9.218	6	0.000
Quarantine for 10 days all new Work Permit holders and Employment Pass holders entering Singapore from SARS-affected countries	3.897	7.489	7	0.000
Quarantine for 10 days existing work permit holders and Employment Q-pass holders who visit SARS-affected countries on their return to Singapore	3.966	8.191	5	0.000
Work with employers to isolate, ring-fence and contain infection in the event of an outbreak of SARS at the workplace	3.879	8.185	8	0.000
Take the temperature of all workers at construction worksites employing more than 25 workers, at least once a day	4.414	16.569	1	0.000
Maintain a temperature log of all workers	4.345	15.433	2	0.000
Ensure that workers are housed in dormitories which have instituted temperature-taking procedures and keeping of temperature logs	4.052	9.462	4	0.000
Urge employers not to send staff for work assignments or training in SARS-affected countries	3.879	7.979	8	0.000
Urge employers to temporarily hold back rotation of staff from Singapore to SARS-affected countries and vice versa	3.810	7.284	9	0.000
Introduce a system to facilitate contact tracing	3.707	4.724	10	0.000

The respondents felt that holding the staff from going overseas or holding back rotation of staff may not be as effective as the rest of the measures because this will further disrupt the work routines of the companies. Instead of holding the staff back, the respondents advocated that the individual going overseas should play a more active and responsible role in maintaining his vigilance in his daily lives by leading a healthy lifestyle and practicing good personal and public hygiene. This will be a more effective measure to guard against SARS.

Introducing a system to facilitate contact tracing is the least emphasized precautionary measure because the construction industry still relies heavily on subcontracting [8], and that it is especially difficult to keep track of all these personnel entering and leaving the construction sites. To enable the optimum utilization of each worker during each working day, the labor subcontractors' workers are transferred quickly form site to site. Hence, personnel entering and leaving the site may not be same everyday and this makes it difficult for contact tracing.

4.4 Possible precautionary measures for the future

Nine precautionary measures that are practiced in other industrial sectors to guard against SARS or other epidemic diseases are suggested by the author (see Table 4) as potential anti-SARS measures that can be adopted by the construction industry in the future. The respondents were requested to rate these measures using the same scale as the precautionary measures implemented. Among the nine possible precautionary measures suggested, all except two have a $p < 0.05$. Hence, it is concluded that these seven precautionary measures suggested to guard against SARS in the future are effective.

To encourage workers on site to have a healthy diet is not considered effective as most respondents commented that they have no control over the food consumed by the workers. Moreover, the construction workers in Singapore are of different nationalities and each may have different preferences for food. Hence, it will be difficult to set a standard of healthy diet for each of them.

Some Japanese contractors in Singapore conduct morning exercises as a warm-up for the daily routine work. This study showed that conducting morning exercises for the workers and staff to reduce their chances of contracting SARS is also not effective. Hence most respondents do not consider morning warm-up exercises as a viable mean to strengthen an individual's immune system and makes him healthier.

The most effective precautionary measure that the respondents hope to implement in the near future is to conduct routine checks on construction sites' hygiene level more than once daily. With a cleaner working environment, the site management and workers not only can safeguard their own health; it also helps to minimize any adverse impact on construction operations if they have to stop work due to poor hygiene or sanitation. The neighborhood will also feel assured, knowing that the construction site and its workers followed strict hygiene standards [9].

Table 4 Results on effectiveness of possible precautionary measures in the future

Possible precautionary measures to be implemented in the future	**Mean**	**t**	**Rank**	***p* (1-tailed)**
Introduce a system to facilitate contact tracing that is specially tailored for construction contractors	3.414	2.507	6	0.008
Produce a detail manual on the procedures for handling suspected SARS cases	3.569	3.747	4	0.000
Include SARS prevention precautionary measures in the planning stage of a new project	3.483	3.569	5	0.001
Send pamphlets regarding SARS matters regularly to sites	3.655	5.270	2	0.000
Conduct routine checks on construction sites' hygiene level more than once daily	3.810	6.530	1	0.000
Encourage workers on site to have a healthy diet	2.983	-0.131	8	0.448*
Encourage workers on site to wash their hands more frequently	3.345	2.351	7	0.011
Conduct morning exercise for the workers and staffs	2.517	-3.404	9	1.000*
Issue personal thermometer to every personnel on site	3.638	4.017	3	0.000

5. Summary and Conclusion

Severe acute respiratory syndrome (SARS) has plagued Singapore for the first few months of 2003. It has affected the daily routine and working progress of the construction industry. Although there have been studies on the effects of SARS on Singapore on a nationwide basis, there has yet been a study that examines the effects of SARS on the construction industry. It is not known if SARS has posed a threat to the construction industry and whether the construction industry has prepared itself against SARS. Even if the construction industry is prepared, it is not known if the precautionary measures taken are effective. There may be more effective measures, which have not been explored. In view of this, this study is conducted to investigate the four issues mentioned above.

Using a structural questionnaire, data were collected from contractors and consultants, clients and other construction related services participants (non-contractors). The locality of respondents and their involvement in construction project during the SARS outbreak period in Singapore were first sought to ensure the relevance of the data gathered for this study. Secondly, their awareness level towards SARS was also investigated.

Next, the preparedness level towards SARS, the impact of SARS as a threat to construction industry and the effectiveness of current precautionary measures practiced and potential measures recommended were investigated. The one-sample t test was conducted to test these four issues in concerned.

The results of the one-sample t test confirmed that the preparedness level of the construction industry is sufficient and adequate. One of the main reasons is the intensive public education and awareness campaigns launched nationwide by the government through the media such as newspaper, television and radio stations. In response to the effort made by the government, the employers spared no effort in maintaining the highest level of vigilance against SARS by taking precautionary measures at the workplace to prevent any import or export of the disease and raise the construction industry preparedness level as a whole.

Secondly, the one-sample t test showed that SARS has not posed a threat to the construction industry. The reason for such finding could be because Singapore had kept a close watch on SARS and responded fast to counter this epidemic disease. As a result, the main parties in construction industry, and the investors, did not lose confidence in Singapore. They went ahead with their planned construction schedules and projects. Most of the employees also went to work as per normal. Hence, on the whole, the SARS outbreak has not appeared to dampen the construction industry activities significantly. However, there are concerns that it is still too early to gauge the impact of SARS on construction industry. The full impact of the SARS outbreak on construction sector may have yet to be felt. There may be delay effects of SARS outbreak on the construction industry. Hence, more studies have to be conducted to further ascertain that SARS has not posed a threat to construction industry.

One-sample t test also confirmed that all the current precautionary measures implemented to keep the workplaces SARS free are effective. Conversely, seven out of nine possible precautionary measures recommended are rated effective. Most of the respondents felt that it is difficult to encourage workers on site to have a healthy diet as they have no control over the food consumed by the workers. Furthermore, it is not viable to set a standard of healthy diet for the workers who came from different countries and have different preference for food. Similarly, the respondents disagree that doing morning exercise would help, as this served as a warm-up for the daily routine work only. It is not possible to strengthen ones health and reduce his chance of contracting SARS through this morning exercise.

This study is beneficial in three ways. First, the study has shown that SARS did not pose a threat to the construction industry. This may be because it the syndrome was only in Singapore for three months. Secondly, it provides a better understanding of the crisis preparedness of the whole construction industry during the SARS outbreak period. The study has shown that construction companies were responsive to adopt additional measures and were well prepared for the SARS crisis.

Lastly, this study has also confirmed that the current precautionary measures are effective in preventing SARS. In addition, other possible precautionary measures that have been practiced in other sectors to deal with SARS or other epidemics are also feasible in construction sector. Should SARS strike again, the construction industry will have better and more effective measures to defend itself against SARS.

Based on the findings, it is recommended that contractors increase their routine checks on the construction sites' hygiene level at least twice per day. This is to ensure that the construction sites maintain a high standard of hygiene and sanitation to prevent the transmission and spread of infectious diseases within the premises. In addition, designing of SARS posters and pasting them on construction site will raise the SARS awareness level among workers. This will help to keep the construction site SARS free as well.

It is also recommended that clients include SARS prevention precautionary measures in the planning stage of a new project. This will enable the consultants and contractors to have better preparation for any suspected SARS case that occurs during the planning or construction stages. Both the clients and consultants are also encouraged to aid in raising the awareness level of the construction workers and operation staffs by sending pamphlets regarding SARS matters and updates to construction sites.

It is also suggested that the relevant organization within the construction industry (for example BCA) should introduce a system to facilitate contact tracing that is specially tailored for the construction contractors. It should produce a detailed manual on the procedures for handling suspected SARS cases in construction sites. This will benefit the construction industry, as the parties in construction sector will have adequate understanding of the necessary procedures required.

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Challenges of Best Practices for Constructability Implementation: North Cyprus Construction Industry

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Abstract

Constructability can be defined as the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Constructability, the integration of construction expertise into all phases of a project, can benefit cost, schedule, quality, and other key objectives. Most organizations participating in the construction industry informally integrate construction knowledge and experience in their planning and design activities. In developing countries, many owners that do not apply formal constructability programs on projects are unaware of the potential savings that are being lost by unnecessary rework, reduced quality, lower construction productivity, and increased schedule durations. Our research focus is to investigate the challenges and opportunities of best practices for constructability implementation in a developing country, the case of North Cyprus Construction Industry. We aim to 1) determine current constructability implementation practices and identify elements that contribute to successful implementation, 2) assess the existence and severity of barriers to constructability implementation and 3) propose methods for overcoming common barriers to constructability in the construction industry of a developing country and develop a framework of best practices for constructability implementation in North Cyprus construction industry. Our research includes review of background literature, interviews with managers on building projects, analysis of this information to develop findings, and extending these to develop a framework of best practices for improving constructability implementation in a developing country, North Cyprus. By carrying out an effective constructability review process in a framework of best practices, the owners and contractors will be able to optimize construction costs, time, quality and safety whilst ensuring minimum interference to existing site operations. This will assist with maintaining consistently high construction performances in North Cyprus construction industry.

Keywords: Constructability, best practices, performance improvement, North Cyprus.

1. Introduction

1.1 Background

Constructability has been defined as 'the extent to which the design of a building facilitates the ease of construction, subject to the overall requirements for the completed building' [1]. Constructability is the optimum use of construction knowledge and experience in planning, design, procurement, and field operations to achieve overall project objectives. Constructability concept is an important tool in improving the quality of a product by controlling for better constructability implementation. Product, being in desired quality is reflected in the growing demands placed on building. The built environment must be constantly developed so that the targets set by residents and the community is attained and the building expresses cultural and environmental values. The importance of the quality of the completed project is growing all the time. The constructability concept encompasses the fulfilment of developer expectations, cost and time savings, ease of construction, functional and technical durability. The owner is responsible for the end product. A good building is the one that will remain serviceable for as long as possible, it will be economic to maintain, and as energy efficient as possible during both construction and use.

Many research efforts have investigated different aspects of constructability analysis. Some researchers have focused on identifying broad constructability concerns and developing constructability improvement approaches and programs [2,3,4,5,6,7]. Others have focused on identifying design-relevant constructability knowledge to automate constructability analysis of 3D models similar to this research [8,9,10,11]. Fischer developed an automated decision support tool that provides feedback to designers on how well a designed structure considers the requirements of construction methods [8]. Fischer presented a Construction Knowledge Expert (COKE) that guides designers towards designing structures that are more constructable [12]. Patty et al. presented a computer tool that utilizes a multimedia to give the designer the capability of accessing constructability information at the point of design [13].

Constructability is increasingly becoming a major requirement in building practice. The industry's clients are continuously demanding the best value for money, in terms of the efficiency with which the building is carried out. Most organizations participating in the construction industry informally integrate construction knowledge and experience in their planning and design activities. In developing countries, many owners that do not apply formal constructability programs on projects are unaware of the potential savings that are being lost by unnecessary rework, reduced quality, lower construction productivity, and increased schedule durations. Recognizing constructability issues early in the project delivery process can help to identify design constraints that limit a constructor's ability to plan and perform construction operations effectively resulting in suboptimal project performance and increased construction costs. Today, project teams often perform constructability reviews during the design phase to ensure that construction knowledge is incorporated in the design process and constructability problems are minimized.

1.2 Constructability Reviews

Constructability Review is the phase of construction project management where an independent and detailed analysis of all of your contract drawings and construction documents is conducted before their release for construction. This critical process evaluates the "ability to construct" the project. The purpose to conduct a constructability review is simply because, during a typical construction project, the design phase can take months or even years to complete in developed countries, while the design phase takes shorter time in developing countries. The problem is that, a contractor's level of expertise and knowledge is introduced at the end of the design phase, mostly by the end of procurement phase, during the time when you bid and award projects to the contractors in order to commence the construction phase. Delaying this vital and project critical review until the later stages of the project can lead to inefficiencies. At worse this will lead to cost overruns, time overruns, substandard building quality, or even structural failure. By the aid of the review, opportunities may arise to perform a framework of best practices for constructability implementation.

1.3 Best Practices for Constructability Implementation

Application of the Constructability Concepts to a capital facilities project can be expected to reduce project costs and schedule while improving quality and project safety. Returns on investment of greater than 10:1 were widely reported. Constructability implementation tools and the roadmap for a corporate or project constructability program were shown in Construction Industry Institute (CII) Special Publications 34-1-*Constructability Implementation Guide* and RS34-2-*Preview of Constructability Implementation* [14]. As demonstrated in the case studies summarized in the publications, when methodically implemented, front-end constructability efforts were an investment that results in a substantial return. Documentation of constructability efforts showed that owners accrued an average reduction in total project cost and schedule of 4.3 percent and 7.5 percent, respectively. These savings represented a 10 to 1 return on the owner's investment in the constructability effort.

In order to commence a formal constructability program, the owners, clients or employers should be acknowledged by professions about the necessity of a formal comprehensive system and enforce them to seek a formal constructability approach. Constructability review conducted in the early stages of a project is useful in detailed analysis of all of the contract documents and construction project drawings and documents before their release for construction. The process involving a constructability implementation should be commenced with the beginning of the design phase of a construction project, sometimes even before the design phase may be useful to assess feasibility of the project in an earlier stage (before the design is commenced) and should be implemented during the construction phase until the delivery of the project. Benefits of early involvement in constructability implementation should be known by the owners in order to obtain a good performance in terms of time-cost quality triangle. Applicability and improvement of constructability approaches are directly related to the approach of the project stakeholders to the constructability concept. For improvement of constructability approaches commence of constructability practices by the involvement of all project stakeholders is of great importance. On the other hand, cost of constructability practices for a specific project should be predicted in order to select the appropriate method or model for constructability implementation.

1.4 The Case: Overview of the North Cyprus Construction Industry

Construction industry in North Cyprus is aware and recognizes the need to modernize in order to tackle the severe problems it is encountering, namely, Profitability, Research and Development, Training, Price and Cost, Dissatisfaction of Clients and Fragmentation. The necessary conditions for competitiveness for the North Cyprus construction industry include strong and sustained levels of productivity growth, openness to innovation and new technology and a commitment to delivering value for clients' money. There is growing interest in the role of innovation within the North Cyprus construction industry [15]. Compared with other industries, there are constraints placed on innovation within construction because of the characteristics of the industry. These include the adversarial culture and fragmentation of the different participants in most construction projects, the project based nature of construction. Projects are discontinuous and temporary and there are often poor linkages between project and business processes. Also the environment within which most organizations operate is changing rapidly. Organizations failing to adapt and respond to the complexity of the new environment tend to experience survival problems, sooner or later. In this climate of change, the development, implementation and use of adequate performance measurement and management frameworks is one of the major challenges confronting organizations but can play an important role in their success.

Contractors typically hire subcontractors, who do not have contracts with the owner - even if the owner pays a high price, the subcontractor may still have to work with inadequate budgets, often compromising quality as a result. Communication tends to be via the contract. Essentially, the designer is paid to produce a design expressed in the form of specifications and drawings. The contractor is expected to use these as a means of communication, and produce the completed facility. This communication often does not work as well as it should have. Innovation is adopted very slowly. Contractors often lack the expertise or financial resources to adopt technological advances - adoption is inhibited further by fear and uncertainty. Few large companies and virtually no small companies have implemented the concept of a quality or productivity manager – the traditional approach is to depend on the experienced staff to run projects efficiently; such staffs are rarely if ever trained in optimization techniques. Profit margins are low and discontinuous in construction industry. Research and development activities carried out by contractors are insufficient. In-house training is not meeting the requirements of firms. Most of the clients are not aware of the difference between price and cost. Thus at the bidding process the lowest offers submitted are preferred by most owners. Projects are unpredictable in terms of timely delivery, within budget and to the required quality standards.

2. Objectives of the Study

Most organizations participating in the construction industry informally integrate construction knowledge and experience in their planning and design activities. In developing countries, many owners that do not apply formal constructability programs on projects are unaware of the potential savings that are being lost by unnecessary rework, reduced quality, lower construction productivity, and increased schedule durations. Our research focus is to investigate the challenges and opportunities of best practices for constructability implementation in a developing country, the case of North Cyprus Construction Industry. We aim to 1) determine current constructability implementation practices and identify elements that contribute to successful implementation, 2) assess the existence and severity of barriers to constructability implementation and 3) propose methods for overcoming common barriers to constructability in the construction industry of a developing country and develop a framework of best practices for constructability implementation in North Cyprus construction industry.

3. Research Phases

The research includes review of background literature, interviews with managers on building construction projects, analysis of this information to develop findings, and extending these to present the key strategic issues that could be targeted for continuous improvement within construction firms in North Cyprus Construction Industry in terms of constructability. The empirical data was collected through structured interviews within the main large private sector construction organizations. The paper deals with the results of a questionnaire survey conducted by research members of European University of Lefke (EUL) Department of Civil Engineering MSc. in Construction Management Program. Main topics in the questionnaire were as follows:

i. General information about organizations
    - General functions of service areas
    - Size of organizations
    - Work capacity
    - Firms' turnover
    - Work force information
ii. Establishment of Corporate Constructability Program
    - Identifying constructability sponsor/champion
    - Establishing functional support organization and procedures
    - Developing lessons-learned file
iii. Planning Constructability Implementation
    - Developing constructability team
    - Identifying and address project barriers
    - Consulting applications matrix and lessons-learned file
    - Developing constructability procedures and integrate into project activities
iv. Implementing Constructability
    - Applying constructability concepts and procedures
    - Monitoring and evaluating project program effectiveness
    - Documenting lessons learned

v. Updating Corporate Program
    - § Evaluating corporate program effectiveness
    - § Modifying organization and procedures, updating lessons-learned databases

3.1 Literature Review

This stage involves a thorough review of literature about the implementation of performance measurement systems that include measures adapted to constructability and that can be a real driver for continuous improvement of project processes. The intensive literature review resulted in the identification of constructability concepts affecting the phases of *Planning* (Strategic Plan/Preliminary Feasibility/Final Feasibility), *Design* (Program or Conceptual Phase/Pre-Schematic Phase/Design Development Phase/Construction Document Phase, *Construction* (Site work/Shell/Interior), *Procurement* and *Occupancy* [14]. The concepts are;

(a) Constructability program is an integral part of project execution plan
(b) Project planning involves construction knowledge and experience
(c) Early construction involvement in development of contracting strategy
(d) Project schedules are construction-sensitive
(e) Basic design approaches consider major construction methods
(f) Site layouts promote efficient construction
(g) Project team participants responsible for constructability are identified early-on
(h) Advanced information technologies are applied throughout project.
(i) Design and procurement schedules are construction-sensitive
(j) Designed to enable efficient construction
(k) Design elements are standardized
(l) Specifications are developed for construction and procurement efficiency
(m) Designed for modularization & preassembly to facilitate fabrication & transportation
(n) Designed for accessibility of personnel, materials and equipment
(o) Designed for construction in adverse weather and remote locations
(p) Design and construction sequencing should facilitate system turnover and start-up.
(q) Contractor use of innovative construction methods

3.2 Data Collection

The second stage involved the collection of data. A questionnaire survey, which was administered to almost all the firms, which are registered to the Association of Building Contractors, has been used in conducting the survey. The survey includes four main types of information involving *Organizational Structure*, *Establishment of Corporate Constructability Program*, *Planning Constructability Implementation*, *Implementing Constructability* and *Updating Corporate Program.*

1. Organizational structure: General company characteristics were sought which include the general functions of service areas of the organizations, size of the organizations involving the production, firms' turnover, number of permanent employees, human resources and development and target group of customers.

2. Establishment of Corporate Constructability Program: This portion of the questionnaire was used to address the steps necessary in establishing a corporate-level constructability program for contractor organizations. The three steps are *Identifying constructability sponsor/champion*, *Establishing functional support organization and procedures* and *Developing lessons-learned file.*
3. Planning Constructability Implementation: This portion of the questionnaire was aimed to analyze the steps leading to effectively planning for constructability implementation. The four steps are *Developing constructability team*, *Identifying and address project barriers, Consulting applications matrix and lessons-learned file,* and *Developing constructability procedures and integrate into project activities.*
4. Implementing Constructability: This portion of the questionnaire was aimed to study the steps for implementing constructability. The three steps are *Applying Constructability Concepts and Procedures, Monitoring and Evaluating Project Program Effectiveness,* and *Documenting Lessons Learned.*
5. Updating Constructability Program: This portion of the questionnaire was aimed to investigate the steps for updating a corporate program. The two steps are *Evaluating corporate program effectiveness* and *Modifying organization and procedures, updating lessons-learned databases.*

The questionnaire was designed using a nominal scale for the real values of the independent variables. In evaluating the dependent variables, a scale of 4 intervals (with a ‘0’ value given to no effect, ‘2’ to a middle value, and ‘4’ given to maximum effect). The respondents were asked to check a number on the scale, which reflects their assessment regarding the different factors (constructability concepts and barriers). A list of all contractor organizations within the construction sector was obtained from the Association of Building Contractors. The list consisted of a total of 30 organizations. An attempt was made to contact every single organization. In this particular survey, the sample size n = 20. During the survey 30 organizations were contacted and 20 (%66) of these questionnaires were evaluated. Contact personnel in the companies for the questionnaire survey were either the top management or senior management in their respective departments, therefore their level of knowledge expected to provide responses was acceptable for the purpose of validity of the survey results.

4. Findings

This section of the study discusses the opportunities and challenges of the implementation of constructability implementation considering construction firms’ strategic planning as well as to the conditions for the North Cyprus construction industry to lesser the barriers for constructability implementation.

4.1 Determination of Importance Indices

The participating contractors provides numerical scoring concepts expressing their opinions on the significance of each concept in determining the establishment, planning, implementing and updating the constructability program and presenting the key strategic issues that could be targeted for continuous improvement within construction firms in North Cyprus Construction

Industry. The weighted average for each factor was calculated and then it was divided by the upper scale of the measurements in what is referred to as "important index" therefore the level of importance of the fourteen factors of the seven phases of the constructability implementation process were calculated using the formula [16]:

$$\text{Level of Importance (Index)} = [\Sigma(aX) \times 100] / 4$$

a= the score given to the factor by each organization (varying from 0-4)
X= n/N
n= Frequency of organizations
N= Total number of participant organizations

		RANK	CONCEPT \ PHASES		PLANNING			DESIGN					CONSTRUCTION			PROCUREMENT		OCCUPANCY	
					Strategic Plan	Preliminary Feasibility	Final Feasibility	Program or Conceptual Phase	Pre-schematic Phase	Schematic Phase	Design Development Phase	Construction Document Phase	Sitework	Shell	Interior	Prior to Completion of CD's	After completion of CD's	Prior to Completion of CD's	After completion of CD's
Σ	682		Constructability program is an integral part of project execution plan	SUM	54	54	68	46	36	36	36	36	36	36	36	54	54	54	46
Mean of Imp. Index	28.50	6		IMP.INDEX	42.75	42.75	57	28.5	14.25	14.25	14.25	14.25	14.25	14.25	14.25	42.75	42.75	42.75	28.5
				MEAN	3	3	4	2	1	1	1	1	1	1	1	3	3	3	2
Σ	752		Project planning involves construction knowledge and experience	SUM	54	54	54	68	54	54	54	54	36	36	36	54	54	54	36
Mean of Imp. Index	36.10	2		IMP.INDEX	42.75	42.75	42.75	57	42.75	42.75	42.75	42.75	14.25	14.25	14.25	42.75	42.75	42.75	14.25
				MEAN	3	3	3	4	3	3	3	3	1	1	1	3	3	3	1
Σ	712		Early construction involvement in development of contracting strategy	SUM	54	54	68	54	49	49	49	49	30	30	30	68	30	68	30
Mean of Imp. Index	32.30	4		IMP.INDEX	42.75	42.75	57	42.75	28.5	28.5	28.5	28.5	14.25	14.25	14.25	57	14.25	57	14.25
				MEAN	3	3	4	3	2	2	2	2	1	1	1	4	1	4	1
Σ	593		Project schedules are construction-sensitive	SUM	54	54	68	49	30	30	30	30	30	30	30	49	30	49	30
Mean of Imp. Index	23.75	14		IMP.INDEX	42.75	42.75	57	28.5	14.25	14.25	14.25	14.25	14.25	14.25	14.25	28.5	14.25	28.5	14.25
				MEAN	3	3	4	2	1	1	1	1	1	1	1	2	1	2	1
Σ	609		Basic design approaches consider major construction methods	SUM	30	49	49	68	54	49	30	30	30	30	30	54	30	30	46
Mean of Imp. Index	24.70	13		IMP.INDEX	14.25	28.5	28.5	57	42.75	28.5	14.25	14.25	14.25	14.25	14.25	42.75	14.25	14.25	28.5
				MEAN	1	2	2	4	3	2	1	1	1	1	1	3	1	1	2
Σ	579		Site layouts promote efficient construction	SUM	30	49	30	54	54	68	54	30	30	30	30	30	30	30	30
Mean of Imp. Index	23.75	15		IMP.INDEX	14.25	28.5	14.25	42.75	42.75	57	42.75	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25
				MEAN	1	2	1	3	3	4	3	1	1	1	1	1	1	1	1
Σ	720		Project team participants responsible for constructability are identified early-on	SUM	46	54	54	54	54	68	54	54	30	30	30	54	30	54	54
Mean of Imp. Index	35.15	3		IMP.INDEX	28.5	42.75	42.75	42.75	42.75	57	42.75	42.75	14.25	14.25	14.25	42.75	14.25	42.75	42.75
				MEAN	2	3	3	3	3	4	3	3	1	1	1	3	1	3	3
Σ	756		Advanced information technologies are applied throughout project.	SUM	30	49	54	54	68	54	54	54	54	54	54	49	49	49	30
Mean of Imp. Index	36.10	1		IMP.INDEX	14.25	28.5	42.75	42.75	57	42.75	42.75	42.75	42.75	42.75	42.75	28.5	28.5	28.5	14.25
				MEAN	1	2	3	3	4	3	3	3	3	3	3	2	2	2	1
Σ	627		Design and procurement schedules are construction-sensitive	SUM	30	30	30	54	68	54	54	54	30	30	30	54	30	49	30
Mean of Imp. Index	27.55	8		IMP.INDEX	14.25	14.25	14.25	42.75	57	42.75	42.75	42.75	14.25	14.25	14.25	42.75	14.25	28.5	14.25
				MEAN	1	1	1	3	4	3	3	3	1	1	1	3	1	2	1
Σ	622		Designed to enable efficient construction	SUM	30	30	30	54	54	68	54	54	30	30	30	49	30	49	30
Mean of Imp. Index	26.60	9		IMP.INDEX	14.25	14.25	14.25	42.75	42.75	57	42.75	42.75	14.25	14.25	14.25	28.5	14.25	28.5	14.25
				MEAN	1	1	1	3	3	4	3	3	1	1	1	2	1	2	1
Σ	619		Design elements are standardized	SUM	30	30	30	54	54	54	68	54	30	30	30	30	30	49	46
Mean of Imp. Index	26.60	10		IMP.INDEX	14.25	14.25	14.25	42.75	42.75	42.75	57	42.75	14.25	14.25	14.25	14.25	14.25	28.5	28.5
				MEAN	1	1	1	3	3	3	4	3	1	1	1	1	1	2	2
Σ	536		Specifications are developed for construction and procurement efficiency	SUM	30	30	30	30	30	54	68	54	30	30	30	30	30	30	30
Mean of Imp. Index	20.90	16		IMP.INDEX	14.25	14.25	14.25	14.25	14.25	42.75	57	42.75	14.25	14.25	14.25	14.25	14.25	14.25	14.25
				MEAN	1	1	1	1	1	3	4	3	1	1	1	1	1	1	1
Σ	646		Designed for modularization & preassembly to facilitate fabrication & transportation	SUM	30	30	30	54	54	54	68	54	30	30	30	54	49	49	30
Mean of Imp. Index	28.50	7		IMP.INDEX	14.25	14.25	14.25	42.75	42.75	42.75	57	42.75	14.25	14.25	14.25	42.75	28.5	28.5	14.25
				MEAN	1	1	1	3	3	3	4	3	1	1	1	3	2	2	1
Σ	603		Designed for accessibility of personnel, materials and equipment	SUM	30	30	30	54	54	54	68	54	30	30	30	30	49	30	30
Mean of Imp. Index	25.65	11		IMP.INDEX	14.25	14.25	14.25	42.75	42.75	42.75	57	42.75	14.25	14.25	14.25	14.25	28.5	14.25	14.25
				MEAN	1	1	1	3	3	3	4	3	1	1	1	1	2	1	1
Σ	598		Designed for construction in adverse weather and remote locations	SUM	30	30	30	49	54	54	68	54	30	30	30	30	49	30	30
Mean of Imp. Index	24.70	12		IMP.INDEX	14.25	14.25	14.25	28.5	42.75	42.75	57	42.75	14.25	14.25	14.25	14.25	28.5	14.25	14.25
				MEAN	1	1	1	2	3	3	4	3	1	1	1	1	2	1	1
Σ	689		Design and construction sequencing should facilitate system turnover and start-up.	SUM	30	30	30	30	49	54	54	54	68	54	54	54	49	49	30
Mean of Imp. Index	31.35	5		IMP.INDEX	14.25	14.25	14.25	14.25	28.5	42.75	42.75	42.75	57	42.75	42.75	42.75	28.5	28.5	14.25
				MEAN	1	1	1	1	2	3	3	3	4	3	3	3	2	2	1
Σ	531		Contractor use of innovative construction methods	SUM	30	30	30	30	30	30	30	30	68	49	54	30	30	30	30
Mean of Imp. Index	19.95	17		IMP.INDEX	14.25	14.25	14.25	14.25	14.25	14.25	14.25	14.25	57	28.5	42.75	14.25	14.25	14.25	14.25
				MEAN	1	1	1	1	1	1	1	1	4	2	3	1	1	1	1
				Rank	11	9	8	3	4	2	1	5	12	14	13	6	10	7	15
			Phases carrying the highest levels of Importance	Sum	622	687	715	856	846	884	893	799	622	589	594	773	653	753	588
				Mean of Imp. Index	21.79	25.15	27.66	36.88	36.04	38.56	39.40	33.53	20.96	18.44	19.28	31.01	21.79	27.66	18.44

Table 1. Matrix showing the variations in the level of Importance Indices of the factors

Table. 1 shows a matrix of variations in level of important indices of the factors (constructability concepts and barriers) during the constructability implementation phases. The X-axis of the matrix indicates the processes categorized into five phases. The three concepts believed to have influences on the constructability implementation process were listed in the Y-axis of the matrix with their index values. The matrix also includes the calculated sum, mean and the rank orders of all the phases of the process listed at the bottom of X-axis with their index values. Studying the matrix the first three concepts carrying the highest level of importance are; *Advanced Information Technologies are applied throughout project*, *Project planning involves construction knowledge and experience* and *Project team participants responsible for constructability are identified early-on*. In observing the three highest ranked phases of the processes, it can be noted that all these phases belong to the "Design" process and carry almost similar level of importance. These are; *Design Development Phase*, *Schematic Phase* and *Program or Conceptual Phase*. The Level of Importance Indices for the concept "Advanced Information Technologies are applied throughout project", the Level of Importance Indices for the concept "Project planning involves construction knowledge and experience" and the Level of Importance Indices for the factor "Project team participants responsible for constructability are identified early-on" are shown in Figure 1., Figure 2. and Figure 3. respectively.

4.2 Discussion of the Survey

The concept "Advanced Information Technologies are applied throughout project", is ranked #1 and is found to have an influence on the "Pre-schematic Phase" considerably with a value of importance index, 57. This indicates that there must be an efficient utilization of Information Technology tools for the storage of historical data. These data are stored by computerized databases. These databases must include lessons learned from the constructability program as part of the project control system (e.g. budget amounts, change orders, and purchase orders).

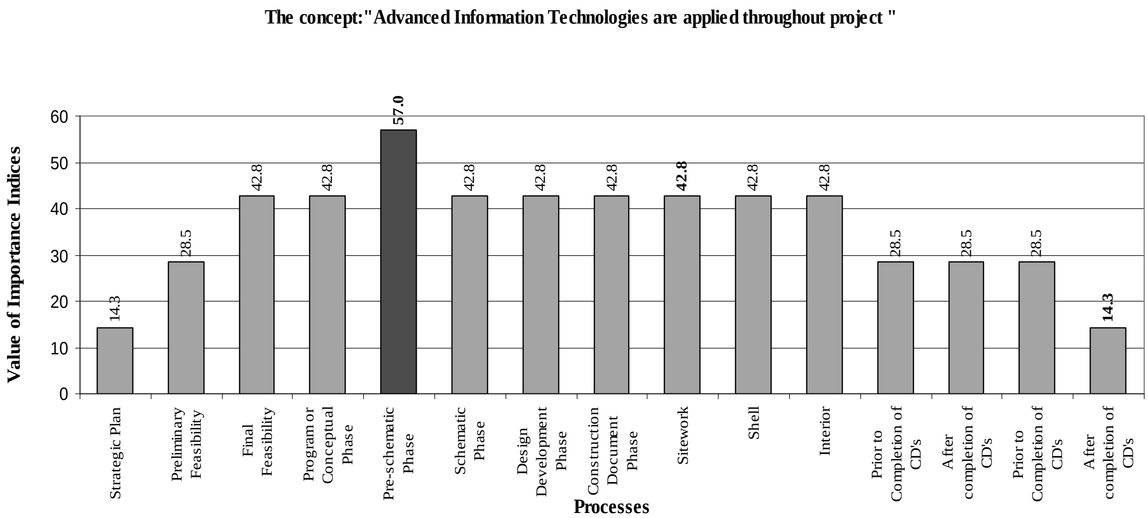

Figure 1. Level of Importance Indices for the concept "Advanced Information Technologies are applied throughout project".

The concept "Project planning involves construction knowledge and experience", is ranked #2 and is found to have an influence on the "Program or Conceptual Phase" considerably with a value of importance index, 57. This indicates that gaining knowledge from past experience is essential to any successful constructability program. Lessons learned are usually communicated by project kick-off meetings, informal conversations, project meeting notes and post-project review meetings.

The concept "Project team participants responsible for constructability are identified early-on", is ranked #3 and is found to have an influence on the "Schematic Phase" considerably with a value of importance index, 57. This indicates that at the design phase an organizational chart must be drafted identifying the constructability team participants and delineating their roles.

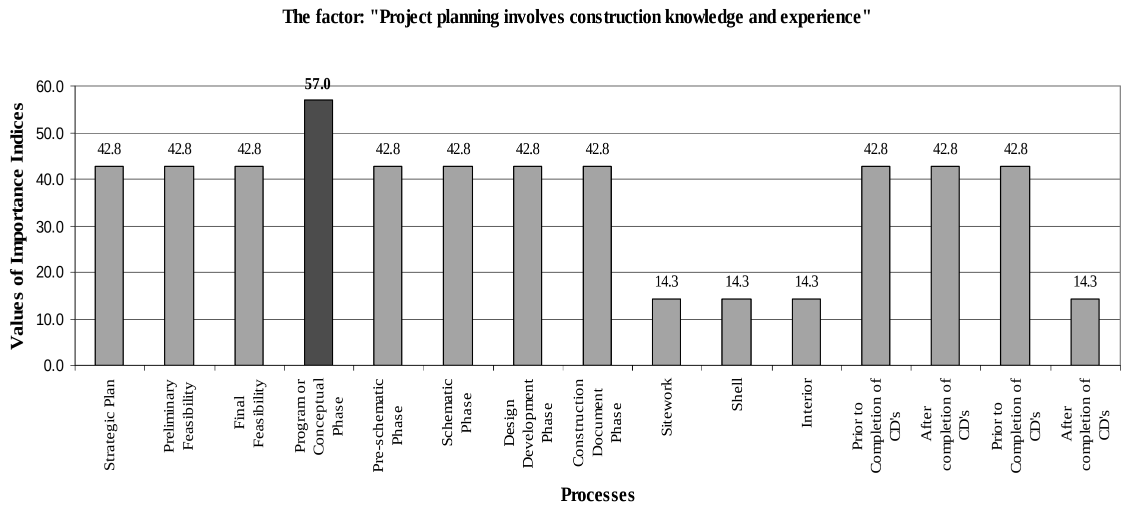

Figure 2. Level of Importance Indices for the concept "Project planning involves construction knowledge and experience".

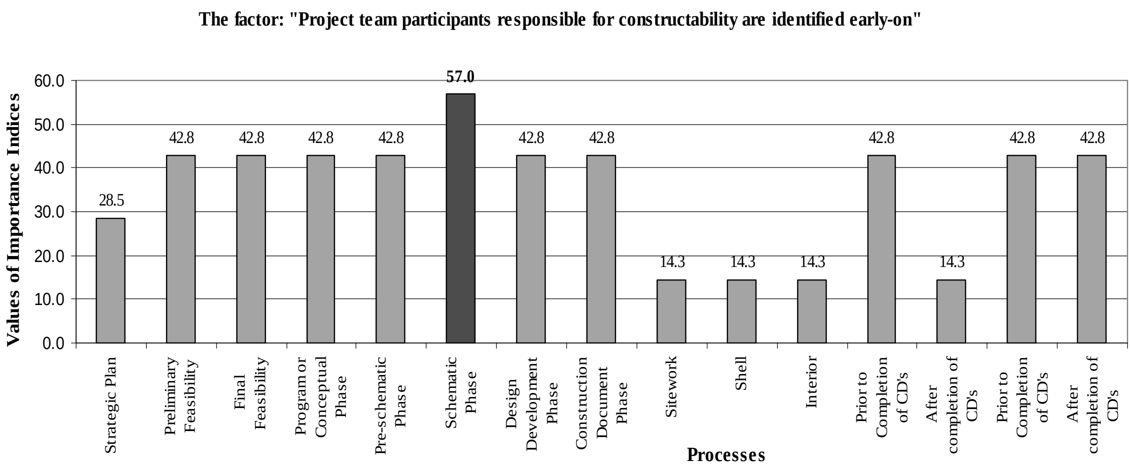

Figure 3. Level of Importance Indices for the concept "Project team participants responsible for constructability are identified early-on".

The survey verifies that the *design* sets the pattern for all that follows. A 'good' design will mean that a 'good' project will follow but a good fabrication and installation cannot compensate for a poor design. It needs to be recognised that design goes through various stages, i.e. concept, scheme, feasibility, detail and production drawings. Furthermore, between each of these stages there is often a break in time, sometimes a change in responsibility and there can even be a change in philosophy and priorities. What has to be achieved therefore is a transition between these various stages without a break, or at the very least with strong links and ties, whilst clearly identifying the responsibilities within each stage. It is important to identify those areas, which, the design must take cognisance of if maximum efficiency is to be obtained.

5. Conclusions

This paper investigates the challenges and opportunities of best practices for constructability implementation in a developing country, the case of North Cyprus Construction Industry. The findings verify that by carrying out an effective constructability review process in a framework of best practices, the owners and contractors will be able to optimize construction costs, time, quality and safety whilst ensuring minimum interference to existing site operations. This will assist with maintaining consistently high construction performances in North Cyprus construction industry. It is found that the concepts "Advanced Information Technologies are applied throughout project", "Project planning involves construction knowledge and experience" and "Project team participants responsible for constructability are identified early-on" hold the highest level of importance. From the phases point of view, "*Design Development Phase*", "*Schematic Phase*" and "*Program or Conceptual Phase*" are the three phases of the "Design" process to be highly affected by the concepts mentioned above.

In North Cyprus, clients are increasingly becoming aware of the benefits of constructability review. They require buildings to be completed on time and within the tender price. These buildings should be of sufficient quality and easy to operate and maintain. Good constructability has been shown from experience to speed up construction, improve standards and lower costs. The time or cost 'saved' in the design process by inadequate attention to constructability is, lost over and over again during construction. Poor constructability can lead to lower standards of construction. The more complex the assembly of the structure is, the greater the number of operations and specialist trades required. New developments in the construction industry highlight the importance and continued relevance of constructability.

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Section II

Shaping Companies with New Managerial Solutions

Best practices – development and implementation

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Abstract

The construction sector deals with huge possible combinations in the use of materials, construction methods, contractual forms, involvement of partners, expertise, etc. The management team in a construction process will be challenged to both satisfy the client demands and to fulfil the operations with a positive return on invested resources. The key to success in such complicated processes would be to minimize expediential options by standardization of processes and structural parts including educational activities for all involved disciplines. Skanska is developing best practices for the purpose to improve the professionalism within the company and to guide involved management levels in awareness and procedures of both "doing the right things" and "doing things right". Dissection and risk assessment of common used materials and structural parts could undermine basic platforms for industries, designers, expertise, etc and would require trustworthy, unassailable expertise and the necessity of involvement from both top management and the academic intellectual capital. The report describes essentials from the identification process of moisture induced problems in construction development processes ending in implementation of results and a moisture plan for business managers, designers and contractors.

Keywords: Standardization, best practice, implementation, moisture induced problems, guidelines, method statements, moisture plan.

1. Introduction

Mould is not a new problem. The incidence of mould has been discussed over many decades and the expression "Sick Building Syndrome" is still in use when the construction sector fails. Moisture is considered to be the main mechanism behind the deterioration of building materials and the cause for mould growth. The mould problem has increased significantly due to shift from robust systems with inorganic materials to more complex systems with many layers of organic materials applied in structures.

Systematic sub optimizations have resulted in a wide range of products in the construction market. The continuous insignificant exchanges of materials in a system as an exterior wall would induce a higher risk exposure. Theoretical considerations would be accurate nevertheless should small defects occur, would materials moisture sensitivity be of great importance.

Analyses of the risk exposure in modern construction of buildings, use of different materials of various degree of moisture sensitivity, the imperfection in weather forecasting, complexity of assembling products under weather shield and resulting in an implementation of more robust products have been a great challenge that will be described in the report.

The management team in a construction process will be challenged to both satisfy the client demands and to fulfil the operations with a positive return on invested resources.

2. Analysis of risk exposure

A Skanska task force with internal and external experts for analyzing the risk exposure for moisture-induced problems in buildings was established 2002. Expert groups were formed for specific studies and focal points appointed from business units involved in the study. The focal points were addressed to handle all contacts to projects and to propose implementation of results from the project.

The first step was to develop a suitable enquiry. All building projects in a construction phase were requested to define used systems in exterior walls, wet rooms, roof structures, basements, basement walls and floor structures. A parallel analysis was set up for detail discussions with site managers about conditions at site, such as planning and control of possible moisture problems.

A probabilistic analysis was performed where the principles of buildings codes were used with the lower 5% fractile as the limit for a low risk structure, see table 1. The assessment took into account both production risks and degradation of materials during the service period. The principle was that building sections should resist mould growth or degradation of organic materials in a 50 year perspective without extraordinary maintenance.

The analysis was focused on moisture mechanics, damages by high moisture load, decrease in material properties, estimated impact on air quality, etc. Material properties were generally lacking nevertheless basic results by Viitanen (1) have been utilized in the categorization of products, see figure 1. Many conditions especially inside structures have been predicted by physical calculations and assumed material properties. The principles for classifying structures were formed by an expert group by description of many typical structures including motivation of the judgment in all sub evaluation steps. Senior experienced engineers were hired to execute the main assessment procedure of enquiries. The results were finally discussed with the expert group for the certification of general findings and for the adjustment of results.

Table 1: Defined risk exposure and principle for estimation of total risk exposure by the combined impact on structural design and sensitivity to moisture during production.

Classified risk exposure	**Probability of damage**
Low risk	< 5 %
Medium risk	5 – 25 %
High risk	> 25 %

Produktion risk	**Estimated total risk exposure in bold**			
Low	L * L = **L**	L * M = **M**	L * H = **H**	
Medium	M * L = **M**	M * M = **M**	M * H = **H**	
High	H * L = **H**	H * M = **H**	H *H = **H**	
	Low	Medium	High	**Service phase**

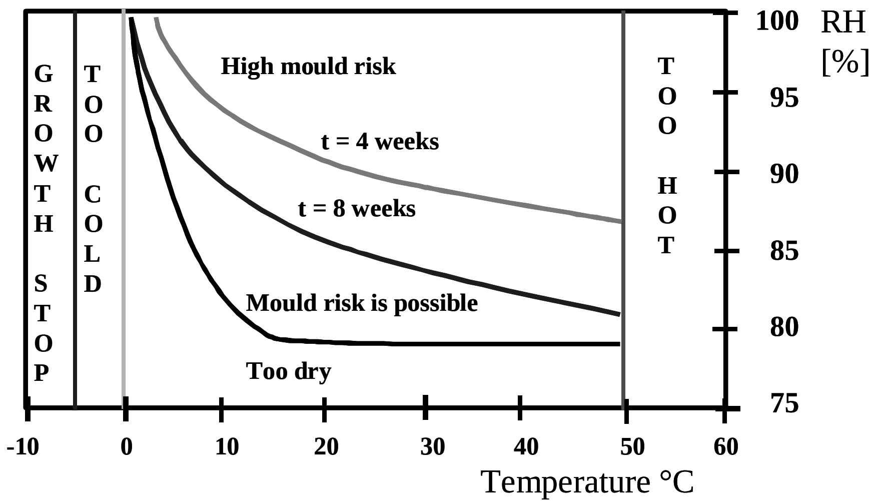

Figure 1: Schematic sketch of possible mould development on painted wood as a function of temperature, relative humidity and exposure time (t). Viitanen (1)

Surprisingly simple structural sections as by way of example exterior wall systems could be varied in more than 250 types even if not all systems were identified. The typical structures of various risk exposures are schematically expressed in figure 2. Cultural differences were observed where the lowest risk exposure was identified in Finland due to their utilization of robust structural systems and materials.

Bathrooms or other wet rooms were generally in the high-risk zone because usages of complex systems with many layers combined with the extremely watery sensitive gypsum plasterboard. The water barrier could consist of various types of membranes some with low ductility properties that would break even with normal movements in structural materials.

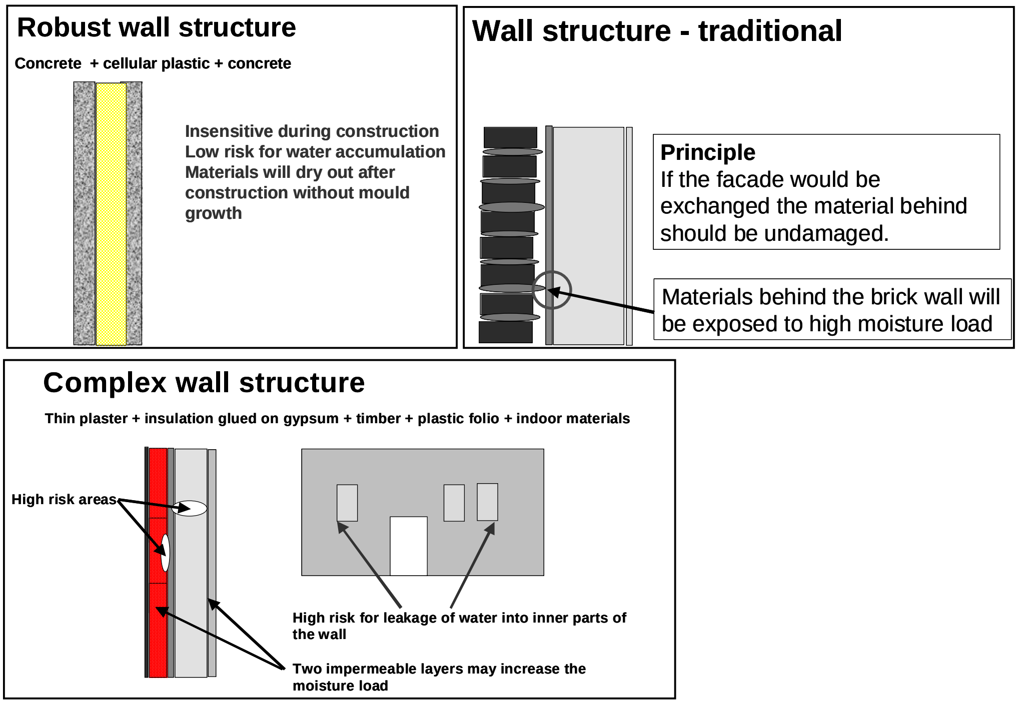

Figure 2: Typical exterior wall structures representing the tree risk exposure grades low (robust), medium (traditional) and high-risk structure (complex).

Theoretically these wet-room structures would be functioning properly conversely the many possibilities to fail would increase the risk exposure significantly. The Finnish system of certification on a personal level for assembling wet rooms with focus on control of membrane thickness, surface slopes etc has been very successful. Arguably assembling both vapour barriers and water membranes, which will encapsulate some materials between two impermeable layers. Detail design for this extraordinary sensitive structural part is normally lacking and enforces construction sites to take decisions and develop details.

Crawl spaces under houses have been in focus later years and many failures have recently been reported in the literature. Earlier when the thermal insulation was moderate these structures were dryer caused by the higher air temperature in the crawl space. The new energy standards have resulted in lower temperatures in these areas and increased relative humidity especially during the summer period. The moisture threshold value for mould growth appears to be exceeded. The recommendation would be to increase the temperature in the crawl space or installation of air-drying equipment.

Roof structures would also suffer from the new energy standards as the increased thermal insulation has resulted in colder attics. Condensations at cold areas are a general problem in new buildings and use of inorganic materials will be constructive.

Basements were earlier storage for household materials and tough processes as building heating systems. The surrounding materials were of the robust type as concrete and stone with excellent functionality in wet and harsh conditions. A change to sleeping and relax rooms in basement usage has introduced more moisture-sensitive materials in these areas. The recommended structure is of open character with the possibility to dry out even after flooding that would be expected few times in the lifetime. Few designers are skilled in building physics and therefore considerations involving the lifetime perspective would not be handled accurately.

Concrete ground slabs structures have been studied over tree decades and the importance of proper thermal insulation has been implemented in the construction sector. New introduced systems as floor heating would change the moisture load properties negatively and the recommendation would be to study these systems thoroughly before a more general introduction to market. Moisture plan

3. Moisture plan

Development of society as areas of buildings have been disintegrated in several disciplines such as business considerations in the sales and negotiation phase, architecture constructive design in predesign, cost predictions in the tender phase, purchasing and construction in the production phase and finally documentation and delivery to client. Lacking awareness of moisture-induced problems in buildings would trap the possibility to select optimal material alternatives to structural sections. A moisture plan was developed for implementation of existing know-how improved inducement of standardized systems and optimal materials, see figure 3.

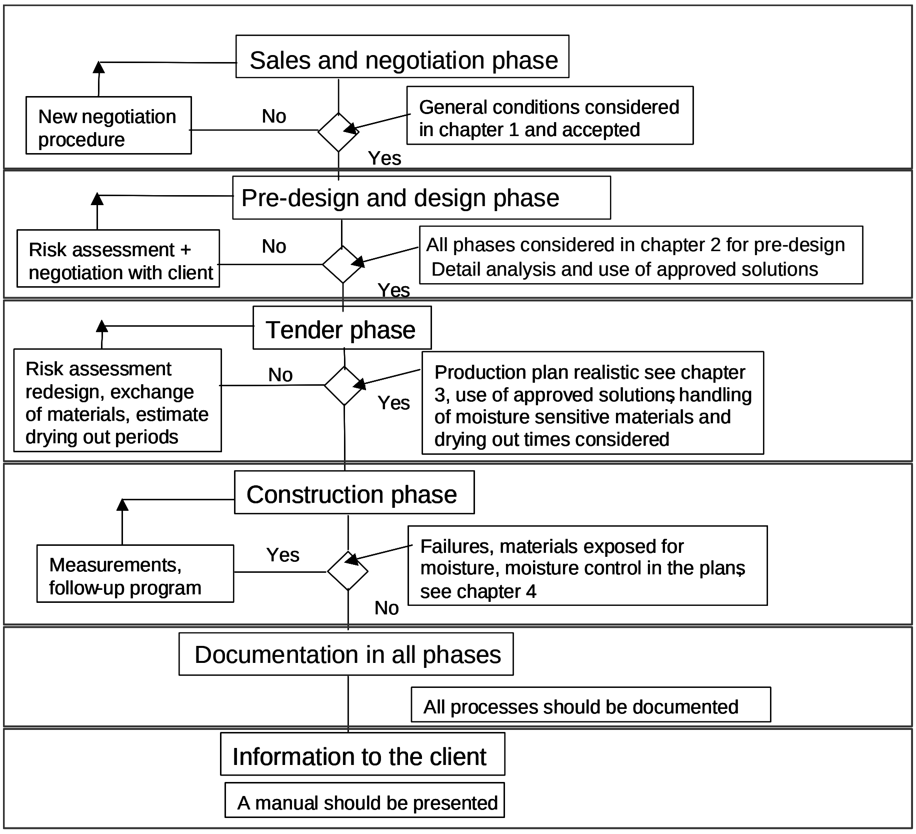

Figure 3: Flow chart of a moisture plan for increased awareness in the construction sector.

4. Implementation

The implementation of technical issues into business-focused employees was a great challenge, especially if the requirement was to reject client proposals in design. The construction market has been totally convinced in that designers would select proper materials with functional properties. On the other hand designers expect the assembly to be carried out in dry conditions, which illustrates the interface problems we have to consider in development of construction systems.

Site managers are also trapped in a cost limit range where exchange of materials would result in higher costs and impossible to achieve. The culture for many years has not accepted interferences from top management to construction sites. Management levels at corporate functions, business operations, purchasing offices and construction site managements have been focused in their optimizations that have resulted in a sub optimization in the holistic view.

In the implementation process the choice was to inform most of the employees of the findings and the risk exposure that would be expected in projects. The aim was to establish a successively change in the production and in business operations. Nevertheless, the transformation to a lower risk exposure was insignificant and a decision was taken to forbid use of specific materials and systems.

A component in the implementation procedure was to develop used best practices. The best practice system has been split in guidelines and method statements. Guideline is a professional information tool for increased awareness and support in selecting procedures aiming in “doing the right things”. Method statements would decrease the efforts in development of manuals and working procedures aiming in “doing things right”. The positive outcome of a best practice system would be the opportunity to focus on prioritized actions as planning of critical steps in the construction process by use of existing know-how.

5. Conclusions

The construction business is acting on a matured market. However, many systems would have been transformed to less moisture robust with increased risk exposure in the endeavour to minimize production costs. A systematic analysis and evaluation of used products and systems have demonstrated the need of increased awareness within the construction sector including all steps from architectural design to assembly of materials. Best practices and standardization would be a tool to improve existing systems and development of products.

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Management of Architects Within Architectural Businesses – Cross Case Study Results

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Abstract

The research formed part of a PhD thesis into the behaviour of architectural businesses and the way the industry reacts to change. The thesis divided this research problem by segregating architects' businesses from the whole industry. The problem was further sub-divided by focusing on architectural businesses that were a particular 'culture'. This sub-division led to the research focusing on four specially selected architectural firms. These firms form the basis for the Case Studies. The research further was limited to an exploration of expectations influencing patterns of behaviour of qualified architects: individually, as a group (as interpreted by the Royal Institute of British Architects (RIBA) Strategic Study) [1] and as a business. This framework modelled the emerging propositions, drawn originally from the RIBA Strategic Study, and enabled the qualitative collection of information from the Case Studies. The RIBA Strategic Study identified a need for architects to change their 'way of thinking', in fact to think more strategically. The RIBA Study was brave enough to suggest the USA model for the industries' future, where architects were developers closing the circle from design through to build. The RIBA Study pointed to some drastic changes that were necessary, (namely the separation of architecture into signature, concept, executive, and construction architects) in the strategic thinking of architects' businesses. The RIBA Study was based around a popular theory, relating to the behaviour of firms, based on work by Coxe et al (1980) [2] in the UK supported the work of Maister in the USA which suggested that firms which superpostition are more efficient than firms that stay in the centreground. Coxe's work went on to speculate that there was a design technology continuum that ran from the practice centred businesses (strong ideas) towards the business centred practice (strong delivery) (Maister, 1987. [3]) Maister added those firms that superposition concentrate on a narrow band of technology. The inference being that firms would tend to superposition along the continuum towards being a business centred practice strong on delivery. Rather than adopt the predictive approach used by the RIBA Study a diagnostic approach was preferred by this research. A model of a firm was developed based in Social Learning Theory describing the firm as a human activities system. The object of the model was to explain patterns of behaviour found in firms. This research collected the perceptions of the firm and the perceptions of individual architects within the firm. The intangible nature of this research problem required a sensitive approach by the researcher to correctly interpret the information collected. Social learning theory was used to identify patterns of beliefs within a firm (Denzin 1970) [4] This paper reports on the findings of the cross case study analysis of those four architectural practices using the technique

of socia1 efficiency mapping. Triangulation of the results, using established research techniques identified any patterns that might emerge from the results and assisted in explanation building.

Keywords: Congruence, social efficiency, expectancy theory, superpositioning

1. Introduction

Mapping Social Efficiency was developed in this research and described in detail in, Thompson (2002) [5]. The technique adapts Expectancy Theory to capture the perception and belief individuals attached to goals. The model is based around a matrix of goals, drawn from the application of a fulfilment model of human behaviour and of business behaviour based in the literature. The vertical axis of the Social Efficiency Map includes a hierarchy of typical goals. The horizontal axis is the expectancy of achieving these goals.

2. Modelling Firms' Behaviour

Coxe (et al)'s [2] model distinguishes three main ways in which architectural firms execute their projects (design technologies) and two types of cultures or ethos, which motivate practices (organisational values). This leads to a matrix of six core positionings each characterised by a different mix of appropriate management requirements. In terms of design technology their model distinguishes three types of firm: strong delivery, strong service, strong ideas. In terms of organisational values the model distinguishes, practice centred businesses, business centred practices. "Many (but not all) of Coxe's findings based on their US research are supported by our own UK observations" RIBA (1992) [1] Two main weaknesses were identified by the RIBA of Coxe's model; first it assumes that for any one box only one set of factors will suit; and second it confuses a useful device for reflecting internal or peer group perceptions with a mapping or positioning matrix based on client needs and perceptions.

Winch and Schnieder's (1993) [6] Strategic Model of a business indicates four generic strategies for better than average performance in architectural practice. The first dimension is that of project complexity. This measures how demanding the project is in terms of the sophistication of specification, its size, the rapidity of the work required, or other special client requirements. The second is the client's preference for quality – whether the client chooses to emphasise conception or realisation in determining quality. These two dimensions yield four generic strategies, which articulate particular distinctive competencies. They are; strong delivery, strong experience, strong ideas, strong ambition. Few practices within the industry develop the competence to sustain one of the three main generic strategies – the vast bulk, earning average fees or slightly below, are stuck in the middle, with little ability to distinguish themselves from their competitors.

Georgopoulos' Model (1973) [7] developed a systems approach in terms of an input-output model. In terms of output, organisations are classified into three main types: output is some physical product; output is some service; and those whose output is information. Complex organisations export all three kinds of output, but rarely to the same degree or in equivalent amount. On the input side organisations import a variety of material and non-material resources and facilities from the environment. A simple input-output model would not be sufficient to explain the critical processes of resource allocation, of co-ordination of effort, of social and psychological integration, and of organisational strain and its management that occur within, the collective level and individual level in an organisation. An organisation may have excellent inputs in terms of quality cost and amount, but a very poor output because these social-psychological processes may be generating dysfunctions and problematic outcomes for the organisation. According to the model it is necessary to examine the problems at the collectivity level, if we are to learn what they mean for the total organisation as a system. It is also necessary to examine them at the individual level in order to understand and explain member behaviour in the system.

Social Efficiency Mapping Thompson (2002) [5] involves mapping the interviewee’s perceptions of reality rather than the reality itself.

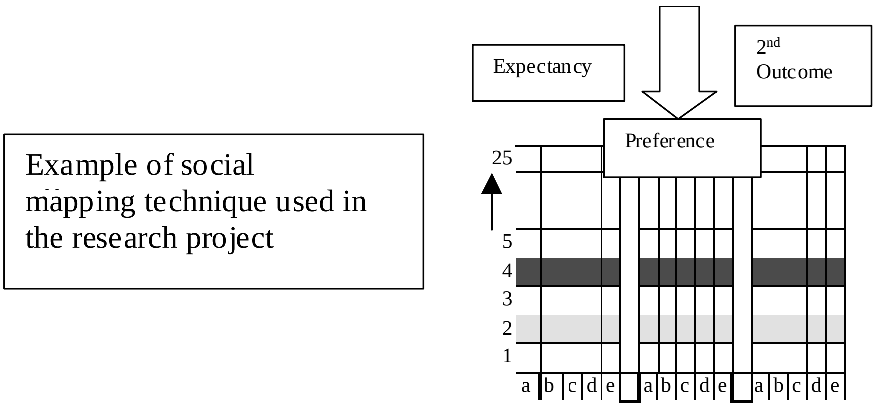

Figure 1 Social Efficiency Map Thompson (2002)

Architects (RIBA) form a homogeneous group of individuals who it is proposed may have a common view of the world, which can be collected, identified and categorised to explain in some part their approach towards business. The effort individuals are prepared to invest in achieving the multiple goals found in organisations has not been mapped previously. This new technique captures individuals’ high level goals and maintenance level goals McGregor (1960) [8] and business goals Barnard (1981) [9] A questionnaire was developed comprising two stages. First, semi-structured interview with a representative of the firm to identify the goals of the firm. Second, a semi-structured interview with the architects in the firm, to establish, first, are the goals of the firm possible, second, do the architects prefer these goals, and third if the firm's goals affect any individual goals of the architects interviewed (Table 1). The researcher carries out an interpretation process developed from Vroom’s (1964) [10] work. Answers collected from the interviews can be positive or negative. The answers are plotted on the Social Efficiency Map (Figure 1). The yellow plots are maintenance goals and the green plots are the motivator goals.

The columns marked a, b, c, d, e are the interviewee's. Where a line appears across the map this is indicative of congruence in the firm about a goal. Where a yellow line forms across the Social Efficiency Map maintenance goals are congruent and where a green line forms across the Social Efficiency Map Motivator goals are congruent.

Case Study A – Traditional Architectural Practice. The firm's skills core is to provide small-scale generalist advice for a wide range of buildings, working in a variety of market sectors. The legal entity of the firm is a partnership, comprising six partners, one of which is the financial manager partner. All partners share equal equity. The line on the Social Efficiency Map (Figure 2) illustrates that goal 12 develop employees potential, merits further investigation as follows:

- The perceptions (expectancy) by individuals of the firm's goals demonstrated conflicts between partners, and between architects. A negative goal was identified for goal 12. The partners were in favour of training but felt threatened the workforce would leave once trained. Lack of policy and structure in training within the firm led to dissatisfaction in the people giving the training and the people who were trained.

- The preference of individuals for the goals of the firm demonstrated how much effort individuals are prepared to contribute to the goal 12, the training policy was not being implemented or leading to advancement in the firm. This lack of commitment by the partners was reflected by the architects 'getting what they can' and leaving.

- Comparison between an individual's secondary outcomes and the goals of the firm identified a conflict arose here regarding goal 12. The partner responsible for training 'had enough' and wanted to design. The architects who had received additional training were concerned this was not recognised. The architects' goals for praise were not being satisfied.

Case Study B – Multidisciplinary Architectural Practice. The firm provides a fully integrated in-house service using in-house specialists comprising project management and co-ordination of the design of highly complex serviced buildings and providing structural and quantity surveying services. They also act as a developer. The legal entity of the firm is a partnership. The lines on the Social Efficiency Map (Figure 2) illustrates that goal 6 gross profits, merits further investigation as follows:

- The perception (expectancy) by individuals of the firm's goals demonstrated uncertainty between partners, and architects. A negative goal was of particular interest for goal 6. A clash arose between partners and the architects because of the policy of not telling staff if the firm makes a profit or not. Architects are not told about any financial matters of the firm.

- The preference of individuals for the goals of the firm demonstrated how much effort individuals are prepared to contribute to goal 6. The partners want the firm to make a profit but it is not, moreover they do not know what to do about it. The secrecy means staff are unaware of the situation and cannot help.

- Comparison between an individual's secondary outcomes and the goals of the firm identified that a conflict arose between competing goals of the firm and the individuals regarding goal

6. The poor financial performance was hidden through partners cutting their personal income. This was kept a secret, perhaps in order to maintain a secondary goal of the partners, which was that of maintaining their image of success.

Case Study C – Named Architectural Practice. The firm’s skills core is to provide highly innovative specialist designs. The firm spends a lot of time designing and co-ordinating the design of highly complex serviced buildings and private houses. The line on the map (Figure 2) illustrates that goal 19 completion deadlines, merits further investigation as follows:

- The perception (expectancy) by individuals of the firm's goals demonstrated uncertainty between partners and architects. A negative goal was identified for goal 19. All the architects knew the firm had to hit deadlines and worked very hard to achieve this, working excessive overtime particularly during design competitions.

- The preference of individuals for the goals of the firm demonstrates how much effort individuals are prepared to contribute to goal 19, the need to win competitions was taking a toll on the associate (b) and architect (d). They realised winning these competitions was the only way the firm had to survive. The adrenaline rush after winning the competition was addictive but the requirement for the architects to be personally responsible for the job to completion of the building was very demanding.

- Comparison between an individual's secondary outcomes and the goals of the firm identified all the interviewees felt the strain attached to goal 19. This reduced their capacity to work effectively due to exhaustion. They had no social lives but were beginning to redress the in-balance between work and private life.

Case Study D- “Commercial” Architectural Practice. The client base is commercial type clients acting as project managers and architects for a supermarket chain store. The firm has four directors and is a Limited Company. As this was the only identifiable commercial practice in the RIBA Directory in the correct location this firm was of particular interest. The Social Efficiency Map (Figure 2) initially appears to be of little use. The firm employs two architects, one of which refused to participate in the study. The line on the map (Figure 2) illustrates goal 2 earnings, is investigated as follows:

- The perceptions (expectancy) by individuals of the firm's goals demonstrated conflicts between the manager (f) and the firm. A problem was identified for goal 2. The firm could not be any more efficient. The firm does not employ competent staff at a lower level so could not give them more responsibility and the firm will not pay 'decent wages' to get better staff.

- The preference of individuals for the goals of the firm demonstrated how much effort individuals are prepared to contribute to the goal 2. The firm's policy of cutting overheads in order to maintain profit in a falling market was seen by staff as making them work harder for no reward. Commitment of staff was therefore low.

- Comparison between an individual's secondary outcomes and the goal 2 of the firm to move into new markets was supported, but the idea that the firm was able to compete in this new market was questioned. The new work would be difficult to learn and the firm was not geared up to train people. Initially this would cause earnings to drop. Management would then cut overheads, would not invest more capital in retraining staff and the firm would be back in crisis mode. It is best to 'wait and see' if things don't improve it is best to leave the firm.

3. Triangulation

The research model needs to be validated in order to compare contrast and interpret the results gathered in the semi-structured interview process by multiple sources of evidence. The advantage gained is by using converging lines of enquiry through a process of triangulation Yin (1994) [11]. Any finding or conclusion in the case study is likely to be much more convincing and accurate if based on several different sources of information.

- Categorisation of the firm, a study by the RIBA (1993) [12] used Maister's framework to identify the many cultural and operational differences found in architectural practices. The study also categorised firms into stages of development.

- Testing by means of standard questionnaires developed for identifying: personality type; creativity; locus of control and leadership style.

- Perceptions collected by a semi-structured interview developed by this research.

- Participant Observation: contact with the informant is so brief and perhaps superficial and the informants may be misunderstood by the observer. This is minimised by following three stages of analysis, the selection and definition of problems, concepts and indices, the frequency of the phenomena and the incorporation of the findings into the case study.

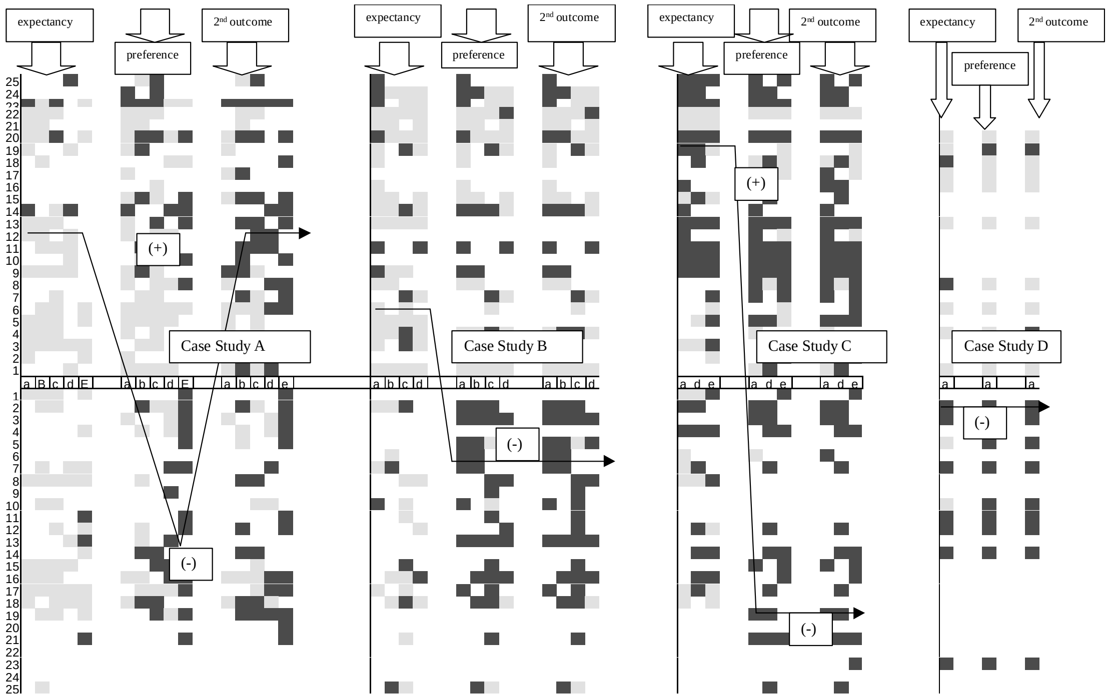

Figure 2: Case Study Results Thompson (2002)

4. Cross Case Study Analysis

A process of triangulation was carried out to identify patterns that emerge from the case studies, and a summary and general conclusion about each case study was made. The proposition is then introduced and the same sequence is followed. pattern matching and explanation building are used to support or question the validity of the proposition.

Case Study A. General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed unevenly between positive and negative goals at the higher levels of goal-seeking behaviour. The maintenance level goals (yellow) predominate at the lower levels of goal-seeking behaviour. A brief analysis of the Social Efficiency describes the firm as chaotic internally with a lot of negative goals held by the architects within the firm. Deeper analysis illustrates the firm thrives on this chaos but contains the stresses and strains generated by the conflict through a high staff turnover. The hold the partners have on the definition of 'good design' acts as a barrier preventing the architects winning any challenge they may have to the partners' supremacy. The consequence of this uneven battle is high staff-turnover, as increasingly confident architects become frustrated with the partners' attitudes to design and move on. This is positive to the firm as it draws in new ideas from the environment through churning staff, rather than strategic thinking by the partners. Social efficiency between the partners is strong but this is not allowed to over-spill into the remainder of the firm because management is strictly retained at partnership level.

Case Study B. General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed predominantly negatively and occur at the higher levels of goal-seeking behaviour, the maintenance level goals (yellow) only occurring as positive goals. A brief analysis of the Social Efficiency describes the firm as approaching a crisis or revolution point in its life. The senior partner's position is undermined by a lack of belief by the architects in the firm's goals, and a strong secondary belief that the firm should change. This unanimity amongst architects anticipating change constrained individuals acting independently and leaving the firm en masse, so much so that the phenomena of a special language had developed amongst this growing clique. The language had grown out of the stifling of individual expression within the firm through a large number of meetings and an inability to make decisions independent of the meeting. The senior partner keeping secret any financial matters from the rest of the firm compounded this practice of cosseting the staff. The trigger to initiate change is the crisis of falling profits. The policy of partners subsidising the firm by continually reducing their earnings from the firm was undermining the partnership's faith in the senior partner's abilities. The focus for change fell on the partner (b) who interestingly had the most effective management style and very different goals to the senior partner. The pattern of the Social Efficiency Map indicated a firm that was not very socially efficient in terms of a business. The individuals did not feel the goals of the firm were achievable or resulted in any secondary outcome that they wanted. But the very unanimity of this negative perception meant that within the firm was a very Socially Efficient clique, in effect the firm was negatively very Socially Efficient.

Case Study C. General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed predominantly positively and occur at the higher levels of goal-seeking behaviour. Few maintenance level goals (yellow) are apparent in the firm. A brief analysis of the Social Efficiency describes the firm as very united regarding the higher level self-actualisation goals in the firm while the more common business goals were ignored. The beliefs of the architects appear to be copied from the principal. The language used in the firm meant phrases used like 'quality building' had definite meanings. The principal was considered to be a master and the architects were learning the craft from him. The questionnaires identified all the architects as type A competitive individuals but with an external locus of control. This indicated they believe forces beyond their control are responsible for success. The combination of these forces mixed to form a powerful cocktail of united thought and actions.

Case Study D. General observations of the Social Efficiency Map (Figure 2), indicate the motivator (green) goals are distributed predominantly negatively and occur at the lower levels of goal-seeking behaviour. Few maintenance level goals (yellow) apparent occur positively at the higher levels of goal-seeking behaviour within the firm. A brief analysis of the Social Efficiency describes the firm's goals as contrary to those of the architect's secondary goals. The architect had developed a coping mechanism to divorce himself from the dehumanising environment of the workplace. Only an active life outside work enabled him to survive in the workplace throughout each day. The architect's higher level needs seemed to be satisfied by his Christian beliefs and involvement with the Church, and indeed this may have substituted completely the architect's original motivation to be an architect.

5. Pattern Matching

Systems theory was used to understand the behaviour in the firms and explain its reasons by using the input - transformation – output model Kast & Rosenzvieg (1980) [13]. The identification of key characteristics of organisational systems provides a link between the environment and the firm. A set of behavioural patterns can be identified and the outcome of predicted behaviour established. This set of behavioural patterns provides a suitable framework for modelling business behaviour. While not dismissing the validity of other approaches towards modelling business behaviour, the integrated framework offered by the systems theory approach provides a set of behavioural patterns that have been established in previous research. Behavioural patterns identified by systems theory comprise subsystems or components. A system is composed of interrelated parts or elements. This is true for all systems. Every system has at least two of the following elements: Holism, Open systems, Input-transformation-output model, Systems boundaries, Negative entropy, Steady state dynamic equilibrium, Feedback, Hierarchy, Internal elaboration, Multiple goal-seeking, Equifinality. A pattern was seen across all the case studies identifying a relationship between market position and Social Efficiency.

Table 2: Abstract of Goal-Seeking Behaviour and Services Offered, Thompson R F (2002)

Case Study A	Case Study B	Case Study C	Case Study D
Traditional service	Traditional service	Specialist in design	Specialist in design construct
Practice Centred Strong Service	Business Centred Strong Delivery	Practice Centred Strong Ideas	Business Centred Strong Delivery
Multiple goal (Chaotic Negative Entropy)	Multiple goal (Revolutionary Negative Entropy)	Single goal (Entropic)	Single goal (Entropic)

The firms that exhibited multiple goal-seeking behaviour had a very different pattern of goals than those with single goal-seeking behaviour. The input-transformation-output model is used to explain the process in each case study. The outputs are considered as services and identified in terms of strong service, strong delivery or strong ideas. The professional or business culture of the firm is considered as located within the transformation process. The inputs are the jobs that come into the firm.

Case Study A: the firm has varying inputs but maintains the output of a strong service by retaining the transformation process of a professional culture. This leads to chaos internally and a lot of negative goals held by the younger architects. The firm thrives on this chaos containing the stresses and strains generated by the conflict through a high staff turnover. This continual churning of staff at the level of 'architect' draws in new ideas which equip the firm to undertake varying inputs but retains its professional culture giving a strong service to clients.

Case Study B: the Senior Partner is attempting to shift the outputs from strong delivery to strong service and move from a business to a professional culture. The result is a firm approaching a crisis or revolution. The lack of belief by the staff in the successful outcome of the firms' goals supports a strong secondary belief that the firm should return to its established business culture. The situation is manifest in the unanimity amongst architects anticipating change at the top rather than leaving the firm en masse.

Case Study C: inputs are limited to 'enlightened clients'. This is necessary to guard the professional culture which the firm believes enables its output of strong ideas. The firm was united regarding the higher level self-actualisation goals, while the more common business goals were ignored. These strong beliefs appear to be copied from the principal. The firm was totally committed to this way of working, with architects preferring to leave architecture altogether rather than entertain change.

Case Study D: the Managing Director is attempting to shift the outputs from strong delivery to strong service but retain the existing business culture. An inability to attract more of their established inputs is driving the firm towards accepting varied inputs. The architect is sceptical about the firm's ability to learn a new type of work because of the rigidity of the existing transformation process. The architect had disassociated himself from gratifying any higher level goals through work and had developed a coping mechanism to divorce himself from the dehumanising environment of the workplace.

6. Explanation Building

The traditional firm in Case Study A attempted to provide a traditional service to a broad client base. The partners were committed to multiple goal-seeking but limitations in their management skills meant goals were capped to a goal to tackle any job that comes along. The firm avoided entropy because of new ideas drawn into the firm by the continual churning of staff. Social Efficiency of the partners is good, all the partners have the same beliefs and goals. The firm seemingly harmonised its professional culture by its concentration on strong service. The multi-disciplinary firm in Case Study Bs' advantage gained by its multi-disciplinary service was being eroded by the senior partner's reluctance to modernise the firm's working practices. The firm did not appear to be socially efficient and moving towards entropy. Closer examination of the Social Efficiency Map however identified a negative Social Efficiency at secondary level within the firm. The Social Efficiency of this group in isolation is good: the entire group has the same beliefs and goals. The firm has a history of coup d'état and it would appear this is part of a long-term cycle. The conflict between the firms established business culture and the introduction of a professional culture by the senior partner, was compounded by a confusion in output between strong on service and strong on delivery. The named firm in Case Study C was very united regarding the higher level self-actualisation goals, while the more common business goals were ignored. The firm was incapable of displaying the internal elaboration required in a growing firm because of the principal's involvement in every scheme. Inputs were limited to those obtained from 'enlightened clients' and their transformation process was rigid indicating a firm incapable of multiple goal-seeking behaviour. The firm being very much a professional culture strong on ideas. The commercial firm in Case Study D was very defined in the market place but the effect of the Social Efficiency Map was limited as only one architect participated. The internal elaboration of the firm was complex but had grown around a specialist input and the requirement for a specialist output. The firm had become entropic because of its overspecialisation and inability to exhibit multiple goal-seeking behaviour. The result was that the architect had disassociated himself from work. The firm was the opposite of Case Study C. All the goals were at the lower levels and none at the higher levels. The firm was desperate to move towards a strong on service output but retain its business culture. The inflexibility of its transformation process was becoming apparent. Proposition: firms that superposition, are more efficient than firms that stay in the centre ground. The proposition is not supported. Firms may appear on the basis of one measure to be more efficient if they superposition towards strong service, strong ideas or strong delivery. Examination of the Social Efficiency Maps and analysis using the systems theory indicate that those firms that do superposition do not have an even spread of goals preferring to concentrate on higher level goals or lower level goals. The effects of a concentration on higher level goals, typically design, has an effect on stress levels, typically excessive working and fatigue in the staff, an avoidance of multiple goal-seeking behaviour and resulting in a move towards entropy. The effect of a concentration on lower level goals is boredom and a disassociation from work by the employees. The resulting deconstruction of their skills' base combined with an avoidance of multiple goal-seeking behaviour compounds this move towards entropy.

7. Summary and Conclusion

The pressure on management is readily apparent as firms resist the pressure to move along the continuum identified by Coxe towards a business culture. All the firms chosen in the case studies seemed to be crippled by management's inability to exhibit multiple goal-seeking behaviour. Analysis of the spread of goals at strategic level gave them the appearance of mutations of firms rather than the well-balanced well- managed firms one would expect to see. The effect of the proposition was to give an insight into thinking at the strategic level in a firm. Comparing the position of the RIBA Strategic Study in 1993 and the thinking of architects in this study illustrated they had not changed and were not going to change. Architects' businesses remain impermeable to change. Architecture remains a strong professional class separate from the remainder of the industry. This group exhibits strong signs of projecting its own goals into the wider environment in the form of beliefs. This is reinforced by the tradition of design competitions as a method of allocating work within the industry. The initial selection of architectural firms in this way reinforces architects' expectancy of approval from their peers in the world of architecture. The effect of the proposition is to point towards a group of individuals who have a tendency toward group-think.

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Improving Innovation Diffusion: A case study approach to strategy development

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Abstract

The construction industry constantly faces new challenges, which emerge at an ever increasing pace. At the same time, the world of business is full of new management and improvement paradigms, each of which has merits, but which tend to be rapidly replaced with new ones. How can a small/medium organisation find the time and expertise to understand these models and respond accordingly? One solution may be that in future successful diffusion of innovation will be facilitated by positive engagement between higher education institutes and industry and the development of knowledge transfer partnerships (KTPs). The objectives of this paper are to identify activities and processes which facilitate diffusion of innovation in the industry, through engagement, and use experience from examples to develop a strategy for improving innovation diffusion. The paper reviews case studies of successful engagement and knowledge transfer partnerships to develop the model of successful innovation diffusion. The main contribution is a proposed strategy to improve innovation diffusion through the use of "innovation sets".

Keywords: Knowledge Transfer, Innovation, Diffusion, Industry Engagement, Partnership

1. Engagement & Knowledge Transfer

1.1 Global and Industry Drivers

The ability to foster innovation is frequently cited as the key to a successful modern economy. In the UK, for example, the Department of Trade & Industry (DTI) has stated 'We find that the competitiveness agenda facing UK leaders in Government and business reflects the challenges of moving from a location competing on relatively low costs of doing business to a location competing on unique value and innovation. This transition requires investments in different elements of the business environment, upgrading of company strategies, and the creation and strengthening of new types of institutions' [1]. The DTI has developed an innovation strategy in response ‘Competing in the global economy: the innovation challenge’ [2]. In this it is stated that ‘Innovation, the exploitation of new ideas, is absolutely essential to safeguard and deliver high-quality jobs, successful businesses, better products and services for our consumers, and new, more environmentally friendly processes.’

Given this emphasis on innovation it is worthwhile considering what the key drivers are for change in the construction industry and what are the associated implications of these drivers? If it is true that innovation is necessary for a successful economy and for the competitive advantage of the companies that shape it, it will be those companies that can adapt to these changes that will be successful. In an attempt to analyse the ways in which construction companies have to change, and how this might this be accomplished, a review of ‘Constructing Futures and SCRI Strategy’ [3] has been conducted by the Salford Centre for Research & Innovation at the University of Salford. This report considers seven construction future studies from the UK, Sweden, America and Australia. The reports contain many common drivers and implications for the industry as shown in the table below:

Table 1: Most commonly cited drivers and possible implications for the Construction Industry

Drivers	**Implications**
Ageing Population	Smart Buildings & Material
Flexible Working & Living	Sustainability Agenda
Rise of the Individual	Pre-fabrication/Offsite Manufacture
Globalisation	Mass Customisation
Move to Service Industry	e-Everything
Increased Use of ICT	On-Site Automation
Demand for Lifelong Learning	Customer Focus
Sensors & Communication Technology	House building/Infrastructure
Automation	PFI/PPP
Note: Implications in the right hand column are not necessarily directly linked to the Drivers in the left hand column	Self-Build
	Refurbishment
	Planning Restrictions
	Global Competition
	Investing in People
	Professional Judgement

In considering the need to improve innovation diffusion it is necessary to match the knowledge base of issues in the above table that exists in the University sector with the immediate business needs of companies. In an attempt to test these drivers and implications ‘on the ground’ a futures workshop [4] was run in the NW of England in conjunction with SCRI, Constructing Excellence and *n*Crisp. The Futures event, which was attended by 13 regional industrialists and 7 academics, came to broadly the same conclusions as the reports considered in the literature review. The event provided abundant evidence of companies having to adapt to legislation and regulations that are being enacted in response to these drivers. Furthermore, there was agreement that the rate of change required from companies is also increasing. It is against this background that this paper considers the need to improve innovation diffusion from the university as one mechanism that can be used to aid companies in facing up to this challenge.

1.2 The need for Knowledge Transfer

In an increasingly knowledge oriented business environment around the world there is the need for both industry and "knowledge" intensive organisations such as universities to work together to help solve and overcome the problems and challenges that being in business in the 21st Century present. As noted by an executive director of Hewlett-Packard [5], there is a growing opinion in the worlds of academe and industry that the last remaining source of competitive advantage is the development and implementation of new knowledge. Assuming that universities are one location for the development of new knowledge then in order to diffuse this into the world of business where that knowledge will be implemented there is a clear need for industry and universities to engage with each other for mutual benefit.

As has been identified above there are multiple factors driving change in the global economy. What must also change is the relationship which exists between industry and universities. There is a long history of many forms of collaboration – what is required now may be to strategically and deliberately seek relations that will permit the transfer of knowledge and diffusion of innovations. This bringing together of industry and academia will help innovation diffusion but may need to be facilitated through brokerage [6]. In addition, the concept of industry and academia being part of the same supply chain, brought together by an innovation "broker", is something which has driven the development of the ideas presented in this paper.

1.2.2 Multiple Forms of Engagement

So, engagement between industry and higher education institutes (HEIs) takes a number of different forms and each one may be driven by a different purpose, objectives and ultimately, outcomes. There is an increasing amount, and many different types of engagement that occur which facilitates knowledge transfer between the higher education sector and industry, particularly from a UK perspective [7]. Types of engagement identified by Lambert include:

- personal contacts and staff exchanges such as visiting professors / guest lecturers or industry secondments;
- business support and consultancy;
- collaborative and contract research;
- establishment of joint ventures, licensing agreements and spinout companies

Indeed, a stated desire within this report was to encourage increased engagement between industry and HEIs as this would benefit both research and teaching activity; and would provide other spin-off benefits for individual academics and teams of academics.

1.2.3 Some benefits from engagement

In addition to facilitating knowledge transfer through closer relationships, another reason for industry / university engagement is to assist with the development of skilled undergraduates and postgraduates and this also provide a mechanism for improved future knowledge transfer between the two parties. Lambert also identified possible positive outcomes of engagement which will include industry access to the following:

- A supply of skilled graduates and post-graduates;
- Highly skilled scientists and researchers;
- The latest research and cutting-edge technology;
- International networks of academics; and
- Continuing professional development opportunities for employees

In addition, three main themes relating to the supply of skilled graduates and post-grads which must be addressed in encouraging future engagement included matching the skills provided by universities and the needs of business; increasing industry influence upon the curriculum; and developing strategies for industry to recruit and retain the best talent. Developing the 'learning society' and an increasing focus upon 'knowledge' will also increase the emphasis upon Continuing Professional Development (CPD) activities and this is an area where collaboration between universities and industry is currently limited [8]. Here, there is potential to increase professionals' interactions with academia in the future especially if academic qualifications become more practical and relevant [9].

In the built environment sector, a recent study [10] considered different forms of engagement primarily from a teaching and learning perspective, but also identified examples of post-graduate work-place training. The main conclusions that can be drawn from this study is that from a teaching and learning perspective engagement can take many different forms and exist upon a spectrum of informal engagement at one end to more formal, planned interventions at the other extreme. Moving from a teaching perspective, there is also a need to understand more clearly the benefits of engagement in research. Having acknowledged that knowledge transfer can take place in a variety of ways this paper now considers how engagement activity can be fine-tuned for innovation diffusion purposes from a research perspective. The first stage in the development of a strategy for this is to consider lessons learned from two examples of innovation diffusion. Both of these examples commenced in an ad hoc way but resulted in strong partnerships, and interesting outcomes for both university and industry.

2. Case Studies of Knowledge Transfer

The case studies in this paper illustrate two examples of knowledge transfer and innovation diffusion between university and the construction industry. It is in part a response to these case studies that the strategy detailed in the next section was developed. Neither of the case studies involves a startling innovation that is new to the industry or region, nevertheless they both illustrate how a company has successfully worked in collaboration with a university for mutual benefit. They also illustrate how, once a common understanding has been developed, innovation can work as a 'pull' from industry rather than as a 'push' from the university side.

The first case study considers a formal Knowledge Transfer Partnership (KTP), whilst the second presents the development of a relationship in a more informal, yet ultimately also productive manner. A KTP is a UK Department of Trade and Industry scheme designed to help businesses to develop and grow by accessing expertise in the UK's universities, colleges and research organisations [11]. Under the KTP scheme the DTI funds approximately half of the cost of employing a recent graduate (known at the KTP Associate) who would normally have specialist knowledge in the problem area identified by the company. The KTP Associate is supported by a KTP Supervisor based in a local university. The supervisor adds their expert support to the scheme which can last between one and three years.

2.1 A KTP in a Medium Sized Painting & Decorating Company

The Group Chief Executive initiated the scheme as a response to a changing market need. The Egan report [12] with its emphasis on partnering had resulted in key clients developing new collaborative ways of working. Realising that the Group needed to respond to the changing market the company initially proposed the appointment of a best practice manager to modernise the company's approach. However, recruitment consultants were approached to assist in the search and it was these consultants that suggested the use of the KTP scheme.

The Business School of a local university was contacted and the process of recruiting a suitable KTP associate started. Support and expertise was given from the University in the form of a Senior Lecturer in Marketing and the Director of the School of Business Information. It is interesting to note here that the skills required were not construction specific.

The initial work indicated that the group would need to adapt to an industry-wide up-take in partnering. The remainder of the KTP was spent in addressing this need. It was clear that to enter into true partnering arrangements the company needed to gain a deeper insight into their clients' needs. A clients' needs analysis was conducted and in response a benchmarking and Key Performance Indicator system was introduced into the company. This in turn led the company onto a path of trying to adopt a culture of continuous improvement.

As a result of the strategy, the company are now part of the Construction Management Frame Work Community with the UK Highways Agency, as well as establishing several other collaborative contracts with Registered Social Landlords. This success means that the company now only seeks to work collaboratively as part of partnering and framework agreements. The KTP Scheme is now complete and the KTP Associate is employed as a permanent member of staff, as Best Practice Manager. The Scheme enabled the Group to take a fresh look at its future and draw upon external expertise in deciding its way forward. The results have made a real difference to the way the company operates and, indeed, its future strategy and success.

2.2 Informal Knowledge Transfer Arrangement between a University and a Small Heating/Plumbing Installation Company

The previous case study details a knowledge transfer partnership under a formal UK government scheme. This second case study details the knowledge transfer that has taken place under what was initially an informal relationship between the University of Salford and a local heating and plumbing installation company. The original contact between the company and the university occurred at an event under the banner of Constructing Excellence's [13] Best Practice Club network. In the NW of England these events are co-ordinated by the Centre for Construction Innovation [14] which is an enterprise centre of the University of Salford. These events include 'networking' time before and after the event and it was here a discussion took place about business challenges facing the company and some of the possible solutions that the HE sector could offer.

At the time no further action followed, other than the exchange of business cards. However, two months later when a PhD student was seeking small specialist sub-contractors to interview in order to study the take up of best practice and innovation in these type of companies, the idea of making contact with the company again with a view to taking an action research approach to the subject occurred. The company was happy to agree to this. During the two month period of the action research the student was present at high level strategy meetings and gained a good knowledge of the company. Progress meetings between the University and the Managing Director of the company resulted in a specific piece of work being commissioned. The company was part of a framework agreement as a sub-contractor on the local housing refurbishment programme and was under pressure to introduce a performance measurement system. This was an area the university had expertise in. Taken together with the working knowledge that the PhD student had of the company it was a comparatively simple task to put a performance measurement system in place. So successful was this piece of work that the company have now accepted a second student as part of the Chevening Technology Enterprise Scheme (CTES) [15]. The student is working with the company to assist them in the implementation of a wireless asset maintenance and job allocation scheme.

The case study is informative in a number of ways. Firstly it shows again that often the initial collaboration can come about in an unplanned fashion. Only if academics are actively involved and network in industry based activities and events can this chance association occur. Secondly, if the initial discussion had involved the need for the company to implement a performance measurement system it is unlikely that the University would have taken this further. It is not possible to implement a key performance indicator system without a good knowledge of the factors that are critical to the company for business success. The initial action research had enabled this knowledge to be gained and so the implementation of the measurement system could be done with this knowledge already gained. Lastly the current work that the company are undertaking under the CTES scheme is indeed innovative for the sector and size of company. It is only after building the 'common understanding' that is discussed by Johnson [5] that this type of work would be envisaged by both sides.

2.3 Case Study Summary

Both case studies detail university/company collaboration that resulted in significant impact in the way that the companies work. In seeking solutions to their problems neither company had initially considered the university sector. It was, to an extent, by chance that the contacts were made. Neither of the solutions could have been implemented without an initial period of in-company work that enabled a common understanding of the company and its needs and the university and its expertise to be developed. The next section of this paper considers the development of a strategy to deliberately create a situation where this common understanding can be developed coming from either formal or informal beginnings.

3. A Future Strategy: Innovation Sets

So, is there a way in which we can create a situation where this common understanding can be developed more often and in an organised way? The current construction innovation strategy of the UK government is based on two main ideas, firstly, that innovation arises from the ongoing production and exchange of knowledge, and, secondly, that the existing diffusion of knowledge from HEIs to the construction industry needs to be improved. Yet, as the previous section has illustrated, despite the effort put into dissemination of research findings it would seem that more could be done. Reports are published, events are held and websites are created but does the knowledge and innovation diffuse effectively?

Perhaps to make research knowledge transferable, researchers must understand companies and their needs better, and vice versa. Perhaps the best way of doing this is through direct, personal contact. It is with these ideas in mind coupled with the Action Learning (AL) and innovation literature [16-23] and this current UK Higher Education Innovation Fund (HEIF) project [24] that the strategy below, of creating 'Innovation Sets' has been developed. Innovation Sets bring together two developments in the field of business support: AL, with its emphasis on finding solutions to real business problems, and the rationalisation and integration of business support.

3.1 Innovation Sets: What are they, and how will they work?

Typically an innovation set will consist of 4 to 8 people who will come together in order to help each other identify, address and solve real business problems. The sets can be project teams, expert groups, professional development groups, general business improvement (or orientation) groups, or other groups, operating within construction or related industries. They can also be inter-enterprise or intra-enterprise. The level and scope of knowledge sharing and knowledge production will vary from case to case, although the potential for real business improvement is present in each of them. In the case of a project team, consisting, say, of consultants, contract managers, and clients, the level of learning is likely to be collective and the scope is likely to be project specific. In the case of expert groups, which originate in common knowledge, such as PFI or off-site fabrication, rather than common projects, the purpose will be not so much efficient exploitation of opportunities and resources, but exploration of novelty in certain professional areas. Accordingly, the scope of learning is likely to be individual and enterprise specific. Professional development groups usually coalesce around generic themes, such as the norms and values of the profession. Thus, the scope of the learning will tend to be individual and enterprise-specific. The intention of general business improvement (or orientation) groups is to improve the performance of the collective, such as the individual enterprise or a collection of collaborating enterprises. They often do this by developing a shared sense of direction and aligning their structures, capabilities and motivations

The innovation sets will use the principles of AL to ensure that action is taken to put ideas into practice, so that learning generates real business benefits. Sets will meet regularly and at convenient times. Typically, there will be monthly meetings over a period of six months, with the frequency of meetings being higher in the initial formative phase. In some cases, the sets may become self-sustaining, or spawn offshoots. Each group will be supported by a set facilitator with appropriate knowledge and interest in learning in the particular field. The set facilitator will give the group focus, provide administrative support and help the members make use of the network of support provided by HEIs and other business support agencies.

The development of an innovation set will progress through a number of stages, such as those envisioned in Figure 1. The purpose of the first stage is to identify the problem or opportunity and gain a real business-focussed understating of the issue (usually something simple and easy to solve). As the set develops members will begin to identify the ways in which they can tackle the issue. The facilitator will encourage each member to develop and implement an action plan. If individual actions are successful, this will help in solving the problem, and the member can, with the help of other set members, specify the learning and develop areas for further improvement – if not then the member will have learnt more about the problem and the action plan, which can be shared and investigated further at the next meeting.

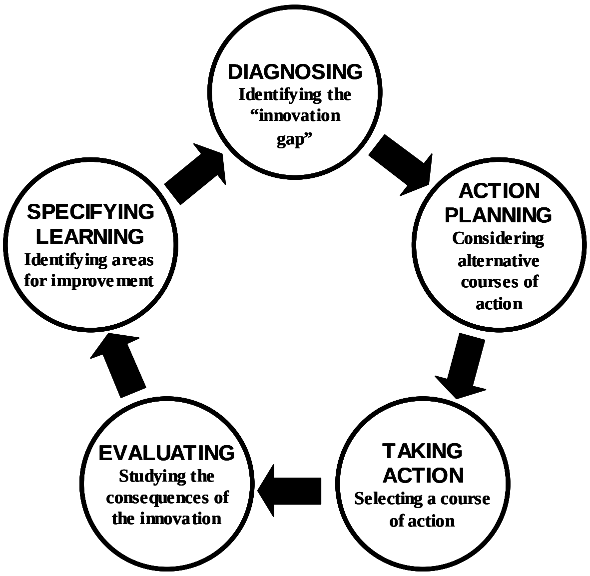

Figure 1: The cyclical process of learning

Unlike traditional action learning sets, each innovation set will be supported by a network of HEIs and other business support agencies. The Construction Knowledge Exchange, as it is known, currently comprises a core membership of regional HEIs and regionally-focussed national agencies. The national agencies are Constructing Excellence (CE); the Construction Industry Council (CIC); the Construction Industry Training Board (CITB), which together with CITB Northern Ireland and CIC forms Construction Skills, the new Sector Skills Council of the construction industry; and the Centre for Education in the Built Environment (CEBE). The network is being managed and co-ordinated by University of Salford with five partner Universities. The partners will work with other regional HEIs and FE colleges; regional centres of the national agencies, local business communities and trade associations; and other bodies to deliver a broad range of business support. This will be available through a web-based knowledge and information portal.

As members of innovation sets, businesses can expect to gain competitive advantages in the areas of overall business performance, individual and business capabilities, internal and external business relationships, and individual and business motivation. Different problems will be tackled by different sets. For those businesses that wish to implement a change process, in response, say, to a change in market structure, innovation sets, in the form of business improvement groups, offer a means to identify the problem and enact suitable solutions, drawing on support from the CKE, including KTPs. For those businesses that want to learn about and engage with generic developments, such as smart building, innovation sets will offer a means for participants to explore ideas and develop their own, business-specific responses.

3.2 Who will benefit? Some important considerations

Studies indicate that action learning sets tend to work best when there is a real business problem; an ability and willingness to act on the problem; and ability and willingness to reflect and learn. Typically, the individuals and the businesses they represent will be seeking to change. This is most likely to occur where futures and choices are unclear. There must also be the ability and willingness to act. Accordingly, the innovation sets must be peopled by senior management or other decision-making bodies. They must also be relatively risk free, in terms of their impact on the psychological and personal career safety of the members, and in terms of the ease with which core-knowledge can spill over and members can free ride on the production of knowledge. Finally, the members must be willing and able to reflect and learn. This presumes independence of thought as well as practice, and a certain degree of competence.

With this in mind, innovation sets are likely to prove beneficial for certain types of business and individuals. They are likely to prove most valuable in developing higher-level professional and managerial competences, such as judgement, and less valuable in developing basic skills, where instruction and practice hold their own [21]. In other words, they promote personal, situational and emergent learning rather than highly transferable, skill-based and programmable learning. They are likely to prove most beneficial in those cases where the prevailing or desired culture of the business is congruent with that of the action learning set. The members must value a questioning approach, respect personal development, trust employees with a fair amount of autonomy, be supported by line managers, and encourage the generation of new ideas. Above all, there must be commitment to implement ideas; action alongside learning.

By placing ability and willingness to act in the forefront of what is learned and knowledge that would help in the background, the innovation sets will, in the words of Revans, help members to "Learn better to manage with and from each other in the course of tackling the very problems that it is the proper business to tackle" [22]. The members will put knowledge into practice and learn how to put knowledge into practice, so they can achieve real and sustained improvements in the performance of their business.

4. Conclusions

Innovation is as a key element of a successful modern economy and by implication for those companies that comprise that economy. At the same time, and reinforcing this idea, the construction industry is faced by a whole range of challenges which occur at a relentlessly increasing pace. As a response to the above, an increased emphasis is now placed on beneficial relationships between HEIs and industry. Given that in the knowledge economy, universities are a key source of new knowledge, it is the contention of this paper that for some construction companies their future success will depend on their being an effective part of this knowledge supply-chain. The case studies illustrate the potential for such collaborations with companies that have previously had little or no involvement with the university sector. The studies further illustrate that real benefits can accrue once a common understanding has been gained.

The strategy of creating innovation sets is intended to help establish this condition on a more regular basis. They are based on the principles of action learning and so start from the concept of defining need and then working together to mutually solve that need. This is an ambitious attempt to strengthen the knowledge supply chain and will provide much useful research material over the coming years. This proposed strategy presents the opportunity to learn more and better about the needs of construction SMEs and to reflect on future courses of action. Evaluation will be undertaken as the different learning sets will be characterised in terms of their knowledge and learning, their motivation and their structure, and to compare this with the corresponding characteristics of the participating business organisations [18].

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Strategies of Roofing Contractors who Develop New Equipments

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Abstract

The aim of this paper is to analyse the strategies of roofing contractors who were awarded for developing new equipments. The case studies confirm that the owners of small enterprises are at the core of the innovation process. Each of the four managers developed products to improve safety on the building site but they followed different development and commercial strategies. One cooperated at the development stage, another at the production level and a third one established a commercial agreement based on trust. The last manager who runs the subsidiary of a large group did not market the innovation. The implication for policy aiming at stimulating the diffusion of innovation in the construction industry is that initiatives should focus more on the commercial stage. Indeed many small enterprises lack human and financial resources to promote innovation at a larger scale.

Keywords : Innovation, construction, small firms, contractors

1. Introduction

The building and construction industry is characterised by a high number of very small firms. In France, in 2000, among the 276 721 firms of the industry, 269 585 (more than 99.9%) employed less than 200 employees and contributed to 79% of the production [1]. Among these enterprises, there is a bulk of very small enterprise. As in countries such as Canada [2] and Australia [3], the majority tends to show little or no innovation. The advantages of large firms are usually ascribed to their greater financial resources and their ability to benefit from complementary resources (technical, financial and commercial).

Firms' positions along the value-added supply chain affect their innovative behaviour. For example, contractors and manufacturers adopt different innovative strategies:

- Contractors tend to innovate by focusing their resources on the effective management of the building site which is considered as their core activity. Most innovations aim at circumventing bottlenecks which, once corrected, enable improvements in productivity and safety of the building site.
- Manufacturers of building components undertake applied research tasks. They focus mainly on extending the range and the performances of existing components. Many innovations are introduced to respond to problems which appear in the implementation

process. Contractors who are their clients want to have products less expensive and easier to install to improve their productivity on the building site.

The fragmentation of the building and construction industry is supposed to inhibits innovation. The use of subcontracting prevents the continuity of teams that is essential to learning and innovation [4]. Because of the fragmented markets, it is also difficult to identify all innovations since most are developed at a local level and result from personal initiatives.

To circumvent this problem and to promote innovations at a larger scale some initiatives have been launched.

Most large French companies created internal contest to promote the best approaches developed within subsidiaries. Their aim is to codify the learning from problem-solving on projects and to disseminate these approaches on future projects [5].

Small to medium enterprises (SMEs) cannot benefit from similar networks and be aware of innovations introduced by similar companies. So national institutions such as the national federal of contractors, the federation of small contractors and the French innovation agency have initiated a national contest to award the most innovative contractors. The aim is to promote the image of the construction industry and the diffusion of innovative approaches and products within the industry.

The aim of this paper will be to analyse the strategies of roofing contractors who were awarded at the national level for their innovative approaches. To fulfil this goal, we will recall some facts about innovation within SMEs. Some elements concerning strategic management will be discussed. This conceptual framework will help us to analyse four cases studies of contractors recently awarded. The findings will allow some recommendations concerning the role of institutional networks aimed at supporting the innovation activity.

1. Innovation in small construction firms

1.1. Definitions of innovation

In their paper about innovation in small construction firms, Sexton and Barrett [6, p.626] define innovation "*as the effective generation and **implementation** of a new idea, which enhances overall **organizational** performance*".

- The implementation aspect shows that innovation differs from invention. "*The invention concerns the creation of a new equipment. The innovation also requires a commercial or practical application of this new equipment*" [7, p.41]. According to its effects, innovation is usually categorized as radical or incremental. However this distinction appears sometimes artificial and arbitrary. For example, the performance improvements caused by the accumulation of minor technological changes may be stronger than the changes caused by radical innovation. Moreover, the difference between incremental and radical innovation is sometimes just a matter of perspective. Certain innovations may be considered as radical from an economic point of view but they rest on minor technical improvements [8].
- The organizational aspect indicates that the innovation concerns either the individual firm or the other elements of the supply chain. This shows that to appreciate the real impact of an innovation, a systematic approach is necessary. It widens the scope of the

analysis by focusing on the firm and its competitive environment. Relationships between the components of the system appear important to understand how actors "*generate, diffuse, and utilize technologies (physical artefacts as well as technical know-how) that have economic value*" [9, p.235].

One way to integrate the links between the components of the building and construction innovative system is to classify innovations according to their impacts on "*core concepts*" and on "*linkages between core concepts and components*" [10, p.12]:

- Innovations are incremental when the core concepts are reinforced and the linkages unchanged.
- On the opposite, innovations are radical when the core concepts are overturned and the linkages are changed.
- Modular and architectural innovations are intermediary. When there is no change in the linkages but a reversal of core concepts, innovation is modular. "*The essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way*" [10, p.12).

The approach shows that an innovation that is incremental to the innovator may be radical to other members of the building site. This means that the implementation and diffusion of the innovation will require defining appropriate commercial and marketing strategies to circumvent the resistance of the users.

1.2. Innovation and strategic management

We will use Ansoff' growth vector' matrix [11] as a framework to describe the position of contractors who developed new roofing equipments.

According to Ansoff matrix, companies can adopt four different strategies:

- maintain their market share without innovation,
- develop new products for their actual markets,
- create new products for unknown markets,
- develop their existing products on new markets.

Markets \ **Products**	Existing	New
Existing	Market penetration strategy	Product development strategy
New	Market development strategy	**Diversification strategy**

A contractor, who develops and markets new products for the building site, adopts a diversification strategy which is the most risky among the four. He moves away from his position within the production chain by producing goods "*for an anonymous market*"[1] where the production depends on the client. This means that the price and performances of his product will be compared with competitive solutions. This change of business orientation raises several issues. This company needs to define an appropriate strategy and to balance the site activity and the industrial activity.

To mitigate the commercial risks associated with a diversification strategy and a new market, enterprises may cooperate with a commercial partner who has already built an appropriate network. Generally, co-operation is sought when activities are closely complementary and dissimilar. Conversely market forces are chosen when "*there is no attempt to match complementary activities ex ante by deliberately co-ordinating the corresponding plans*" [13, p.891].

1.3. The dominant role of the manager during the innovation activity

In SMEs, the manager bears the responsibility of taking the decisions regarding all aspects of technical change. Thus risk adversity may impede the innovation process. Two types of behaviour are usually applicable to managers [14]:

- In the first category, one finds managers who look for the stability and independence of their company and consider that innovation represents a large financial risk. So they only innovate under the pressure of their environment. They limit their contacts with the external environment to suppliers and clients. The management style is centralised.
- The second kind of entrepreneurial managers encourage rapid growth of their company. They accept risk and try to take advantages of every new opportunity. To enhance the performance and the growth of their company, they forge external technical and scientific linkages with educational establishments, research associations and other public agencies. They know that the success of their company is based on the quality of their employees and on their commitments to networks of innovators. In this prospect the managers' educational level influences the scope of the network. Highly educated managers tend to rely more on research and advisory agencies and less on informal contacts. Networks allow SMEs to decode and appropriate flows of information. They reinforce SMEs'competitiveness by providing them with a window on technological change, sources of technical assistance, market requirements and strategic choices made by other firms.

The dominant role of the owner in small construction firms is a source of flexibility and adaptability to any changes in market conditions and client demands. But it "*can constrain innovation activity if the owner does not have the necessary vision and systemic thinking when diagnosing and progressing innovation activity*" [6, p.631-632].

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[1] *"One of the peculiarities of the construction industry as compared to the manufacturing industry, which produces goods for an anonymous market, is that in construction industry the production is depending on the client"* [12].

2. The case studies

2.1. Characteristics of the national award scheme for innovative construction companies

The national Innovation Award dedicated to firms working on the building site was launched in 2000. Since this date, every two years, companies are invited to present innovations that have been successfully implemented. Applications are judged by a jury of people working for the Ministry of Housing, the national federation of contractors, the federation of small contractors, the French innovation agency, CSTB, a journal dedicated to the building and construction industry, regional delegation of the Ministry of Construction…

About 200 applications were submitted in 2000 and 2002. Most came from small construction firms. The most promising innovations were awarded (less than 30 in 2000 and about 40 in 2002). The aim of the organizing committee was not to be elitist but to promote the image of the construction industry and the diffusion of innovative approaches.

Four types of innovations have been identified by the organizing committee:

- Building techniques,
- Safety and work conditions,
- Methods and organizational schemes,
- Environmental approaches.

In 2002, among the innovations awarded, 40% of them aimed at improving safety on the building site; 25% were technical innovations elaborated on the building site, 22.5% concerned the methods and 12,5% were related to environmental matters.

We selected four firms which won the Innovation Awards in 2000 or 2002. The enterprises will be called A, B, C and D to keep them anonymous. This was not a random selection. The four of them developed roofing equipment that improves safety and work conditions of the building site. The interest of such a selection is also to examine the impact of the internal organizational capabilities on the innovative and commercial strategy.

2.2. The cases of four roofing contractors developing new equipments

Company A is a roofer employing about 35 people. The innovation concerns a new scaffolding with different anchorage devices. The goal of the manager was twofold: Firstly, it was to follow the evolution of the regulation concerning anchorage point set-up and safety rules. Secondly, it was to develop a new system to increase the productivity of the working site. After designing the prototype, the enterprise collaborated with a supplier of roofing equipment. The manager considered that his enterprise did not have any human and financial resources to develop the product. Moreover the development of the new scaffolding system would have lead to a risky diversification. Both products and markets would have been new. So the owner and manager of company A preferred to concentrate his resources on his core business and to cooperate with a manufacturer of equipment.

His partner, a supplier of roofing equipment employs 210 people. At that time, he did not have a collective scaffolding system in his range of products. So he was interested in developing this product designed to improve the efficiency on the building site and to ensure a maximum of safety for craftsmen. This company was able to rely on its R&D laboratory and extended the partnership to organisations promoting safety and health on the building sites. The aim was to develop a standardised system that could be used on any kind of roof.

Once the product developed, it was patented in Europe, Canada and the United-States. But the market is still reluctant to adopt the product because it modifies the behaviour of the craftsmen who use the scaffolding. This prevents its diffusion. To reduce the reluctance of potential users, the company created a subsidiary to rent, transport and erect/dismantle on site the scaffolding. By providing this new service, the manufacturer shows that the skills required to erect the product are not so specific. The installation also leads to an increase of the productivity of the building site. The new service helps the roofers to concentrate on their business and not on the erection/dismantling of the scaffolding. Moreover the subsidiary brings its professional approach to building site. Despite the success of the subsidiary, the innovation is a failure. About 1 million euros have been invested by the manufacturer to develop and sell the product. Almost no sales have been recorded. This failure recently led to the development of a new range of scaffoldings with no permanent anchorage. Its installation goes along with the habits of the roofers. Until now the product is quite successful and the sales are even higher than expected by the business plan.

Company B employs 15 people. The innovation concerns a new anchorage system. The regulation was at the origin of the innovation introduced by the manager. Company B used to work on the building site with contractors. One site being closed for not complying with the legal framework, a solution had to be found. The involvement of the manager in the project was very strong. It took him about six month to find an appropriate solution. This research phase required frequent interactions with the contractor. Once the first prototype was operational, cooperation with the Technical Centre for Mechanical Industry was established to reduce the weight of the product. Then the manager received some financial subsidies to patent his product. His brother, who is responsible of the design office of the company, was in charge of the development of the product.

To commercialise the anchorage system, the manager made several demonstration during local professional fairs. After taking out the patent and launching these first commercial initiatives, he decided to look for a trader. He was able to find a sole agent after receiving the Innovation Award. His agent is the world's largest manufacturer of concrete mixers as well as the largest French manufacturer of scaffolding and tubular structures for local councils. To market his products in France, he relies on a large network of sixty salesmen. His interest in the innovation was due to the award. It reinforced his trust in the product.

There is no written agreement between enterprise B and the sole agent. Trust is the cement of the commercial collaboration. The products developed by the innovator are displayed in the catalogue of the manufacturer. Salesmen, who are in touch with the clients, represent the manager of company B and provide him with feedbacks. Then company B sends the products to the enterprises that order them. But the prices are established by the manufacturer (trader) who receives first the cash. At the end of each month, company B sends an invoice to his sole agent (the manufacturer). As mentioned by Richardson, in this case, there is no technological cooperation between the two partners because there is no requirement to match complementary activities. Their commercial relationship is based on market principles and trust.

This first success led the manager of company B to develop other roofing equipments. Anchorage devices and scaffoldings designed to prevent falls from height represent at the beginning of 2005 about one third of the turnover of the company (this business activity did not exist before 2000). This diversification which is very successful, became necessary in 1999 when the traditional business collapsed (the turnover of the three first months of 1999 were equal to the first month of 1998). The risks associated to the distribution have been mitigated. The product is new but the commercialisation of the products is assumed by the largest French manufacturer of scaffolding and tubular structures for local councils who had already built a large and sound commercial network.

Company C is a carpenter and a roofer employing 20 people. The manager developed a new product to comply with the legal framework and to improve the safety of its employees. The collective safety equipment on roof edges was tested within the company. The product was regularly improved thanks to the remarks of the roofers. After patenting it and registering the trade-mark, the manager subcontracted the manufacturing of the product to a small company with whom he already worked. He used the services of a sale agent in the Alps. He also invested some financial resources and dedicated lots of its personal time to commercialize the product on its own. To spur the sales of the product, he opened an exhibition stand at the main professional fairs concerning the building and construction industry. Before the Innovation Award, he was not aware of the quality of his product. But the award gave him some self-confidence. He even used it as a mean to convince the potential users. One organisation promoting safety and health on the building sites provides roofers who buy the products, with subsidies and contributes to the diffusion of the product.

However the sales have been quite limited and they represent today about 7% of the turnover of company C. After spending some of his time to launch the product, the manager decided to focus again on his core business: carpentry and roofing works. He was a little bit disappointed not to receive more assistance during the diffusion of the product.

Company D is the regional subsidiary of a corporation operating in the building and construction company with 2500 people worldwide. In France, 29 subsidiaries cover the territory and employ about 1500 people. The manager who developed the innovation, run a subsidiary employing 120 people specialized in roofing, insulating cladding and waterproofing works. An operative of the building site was at the origin of the innovation. The new system provided an anchorage point set-up on roof edges. It reduced the risks for people working on the roof who were previously anchored on the wall (because it was not possible to make a hole in the aluminium standing seam roofing). Once the product designed, it was produced by an ironsmith who regularly works with the company. The new safety system was used within the company. No patent was taken out because there was no intention to adopt a diversification strategy and to market the new product. The core business of the group was not to sell safety roofing equipment but to work on the building site and to develop new waterproof materials. At the level of the group, 3% of the turnover is dedicated to R&D. But research works, are oriented towards the improvement of waterproof materials. Consequently, it was the supplier of the company who took the idea and integrated the safety system to its aluminium products (the supplier is an international metal company, providing steel and aluminium products to customers worldwide. One of its divisions produces steel and aluminium products for the building industry including roof & wall cladding).

2.3. Synthesis of the case studies

Despite the small sample of our analysis, our results confirm that builders are an important source of innovation. They may even be more innovative than the manufacturer when their business is concerned. A similar result was put forward Slaughter [15] who found that residential builders were the primary sources of innovation relating to stressed-skin panels.

In three cases, the innovations introduced were incremental. They keep the habits of the user by improving their safety. These innovations aimed at circumventing bottlenecks which, once corrected, enable improvements in productivity and safety of the building site. In the three cases (Companies B, C and D), the innovations were an ad hoc response to problems encountered in the course of a construction project. The innovations were solving problems which disrupt the daily activity. The research approach was more by trials and errors than by formal R&D.

The failure concerns the architectural innovation (innovation introduced by company A and developed by a manufacturer). The final output of the manufacturer was not a radical innovation. Basically, the scaffolding was providing the same service as other products (the protection of people working on roofs). But it required roofers to develop different skills to erect and dismantle the scaffolding on site. From their perspective, it could be considered as a radical innovation. The material supplier did not realise the impact of his product on the habits of the roofers.[2] To solve this problem, he created a subsidiary that installs the scaffoldings. The links between the existing components of the system that were disrupted by the innovation, have been reconfigured thanks to this new service. In the long run the diffusion of the product will depend on the strengthening of the statutory requirements concerning roofing equipments (the manufacturer renews every year the patent because he expects a "positive" evolution of the regulation).

These case studies also show that the owners of small firms are at the core of the innovation process[3]. Owners of B and C innovated and developed the innovations (the owner of company A decided to collaborate with a supplier who had technical, financial and commercial resources). Because of the limited number of executives within the enterprise, these two

[2] "*Manufacturers and suppliers who are unaware of the changes required to implement their innovations, either in the links to other components, processes, or systems or in the product itself are likely to meet resistance in the spread of their products*" [16, p.15].

[3] The case of company D slightly differs because it is a subsidiary of a large group. One operative was at the origin of the innovation. But the manager contributed to its implementation within the subsidiary.

managers were in charge of marketing and developing their product. The limited size of these enterprises allows the owner to find quick answers to respond to evolving client demands.

Finally it is interesting to note that the development of a similar product lead to four different commercial strategies:

- Company A collaborated with a supplier and focused on its core business.
- Company B developed the product but left the commercialisation of the innovation to a large manufacturer who had already invested resources to build a large commercial network.
- Company C designed the product but subcontracted its manufacturing and took most of the commercialisation in charge.
- Company D (the subsidiary of an international company) used the innovation for its own sake but did not develop it because it was out of its core business.

3. Conclusions : Implications for national policy aimed at supporting innovative construction companies

These four case studies indicate that regulations are one of the main drivers for innovation on the building site. The four innovations presented in the aforementioned cases were launched to comply with the legal requirements established to prevent falls from height. Enterprises innovated to adapt their organisation to regulations. This result is confirmed by a recent report by SPRU (quoted by [17], p.734). According to this report, "*the most important sources for the construction firms are its suppliers, health and safety regulations, and clients."* Studying energy efficiency in housing, Gann and al. [18, p.291] also considered that "*prescriptive regulations have forced firms to innovate, particularly at the component level, in order to comply with more stringent standards of energy efficiency.*"

The failure of the architectural innovation seems to indicate that building companies lack technical capabilities to understand innovation. According to Cohen and Levinthal [19], firms' ability to exploit external knowledge depends on their absorptive capacity. The reluctance of roofers to adapt the new scaffolding that leads to a change of the way they work, can be due to a lack of qualification. If roofers do not have the absorptive capacity to understand an innovation, then they will not implement it. One way to promote innovation within building enterprises would be to develop training programmes to increase the qualification of employees.

Most enterprises did not realise before launching their products that the commercialisation would be so expensive. It appears that the development costs are smaller than the commercialisation costs. This is particularly striking for company C. The manager would have expected more commercial assistance during the diffusion of his product. The commercialisation of a new product for a new market (to this given firm) appears more complex than technical matters. It also requires more financial resources.

These results indicate that national innovation policies dedicated to building companies should also focus on commercial issues. The creation of a product is just the beginning of the innovation process. Most small firms may think after receiving an Innovation Award that sales will follow. Most of them are not aware of the difficulties associated to the commercialisation of a product. They need to identify the leading customers who could promote the innovative products. They have either to invest their financial and human resources to develop a commercial network or to cooperate with a firm which already knows how to market a new product.

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Section III

Organisational Studies and Innovations

Trust, Participation and Hospital Design – Two Approaches One Result

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Abstract

This paper is based on a study of the change and design process for the surgery and radiology building at Örebro University Hospital, Sweden. The basis for the process is the tradition in the County of Örebro to carry out projects in close co-operation with the users as well as aiming for high quality buildings. Traditionally building design projects were set up in a close co-operation between core business representatives and the real estate department. The building project utilized this cooperative approach.

In the study of the process, two approaches to the co-operation were identified. One (1) trust based process and one (2) participation based process. The trust-based process is characterized by having a respected leader, or a small group, with a strong support among staff that enables them to act for others. The participation-based process is characterized by a larger number of active participants representing all tasks, often in working groups dealing with sub tasks in the design process, and a need to get feed back before any decision is made.

It was found that both of the two processes worked well and that the result is considered as a usable building. This finding is compared with a finding from another study where the issue of discrepancies between client's goals and the outcome, is discussed. The paper discusses the two approaches, how they relate to client's goals and how these affected the process and what can be learnt for future change and design processes.

Keywords: Usability, design processes, participation, hospital design

1. Introduction

Within the Health Care, large investments continually are made in different construction projects. As public finances fund these, it is important that they meet both functional and financial requirements as well as the public eye. Whether a project is a success or not can depend on how well the programming and design process is managed. It is therefore important to study advantages and shortcomings in these processes and develop methods to improve these.

This paper is based on case study of the Örebro University Hospital (USÖ) [1] [2] and a study on experiences by clients on the outcome of construction projects [3].

2. Background

Although the construction trade is skilled in carrying out complex projects and mastering multidisciplinary design and construction projects there is a common opinion among representatives for core business and corporate real estate that the finished projects often do not meet the goals of the core business, or add the expected value to core business [4].

In a study of USÖ, it was found that participation and co-operation between core business and the construction project group supported the development of a usable building. The hospital has a long-term experience from participative building design processes and thus the staff, in both surgery and radiology, knew that involvement was a part of the process - it was never something they had to fight for. In the study of the process, two approaches to the co-operation were identified, one trust-based process and one participation-based process. In radiology, the head of the radiology department and technical manager they were allowed to develop a radiology department, both technically and organisationally, based on digital technique. If these persons had not owned the trust of the staff, the new solution would have faced fierce resistance by staff. The trust allowed for an efficient process where few actors pushed the process and the staff participated only in meetings and were not actively involved until the new radiology department was about to get staffed and completed. In surgery however, there was an active participation in testing and working with a mock-up room where work functions for surgery could be tested for real and not only agreed upon based on a functional specification. The gap between definition of function and real use was thus bridged [1].

Granath and Hinnerson [4] notes in a study on the outcome of design processes in corporate real estate, that a vast majority of the studied real estate professionals agree with the statement that there is a discrepancy, or at least perceived discrepancy, between clients' and core business goals on one hand and the outcome of the construction project on the other hand. The explanations to this are also elaborate and the condition is regarded as a problem. Very few participants experience however that this is a problem in their projects. Problems and threats of deviation from the goals occur but they are mostly solved during the course of the project is one of the arguments. The perceived discrepancy is thus possible due to the actions from the actors in the project itself. The participants just do not admit or realize this. Discrepancies between goals and outcome are thus a matter of communication and participation. Increased knowledge, outside interventions and ongoing development of goals is considered a natural part of the project that can be dealt with, not something that compromises the process.

As the building in the USÖ case is considered usable and appropriate for the core business Health Care, it is interesting to study the two approaches that managed to overcome ambiguous statements in the programming and the interpretations made in the transition to the design phase and how this relates to the findings from the Granath and Hinnerson study.

3. Method

This paper is based on two studies. One on USÖ [1], which focused on the process in the transition from programming to design, and one on the outcome of construction projects [4].

In the USÖ case study, a part of CIB/TG 51 study on Usability, the aim of the investigation was the understanding of a complicated concept rather than finding common quantitative evidence of a certain phenomenon. The study used a qualitative and practice grounded method based on several years of research. A previous and similar research project was the investigation of the multiple aspects of “the importance of spatial design to work place performance”, in which a method for this kind of research was developed [5]. The first component [i] of this investigation is to fuse practice and research together in the development of understanding. Theory developed from practice and theoretical reflection on and structuring of practical understanding are the cornerstones of the investigation. The creative process of investigating and reflecting on common situations between research and practice is essential. This method of developing innovative new concepts that challenges existing theories, as well as proven practice has been successful in earlier projects. The second component [ii] is the combination of self-evaluation by practice based on a selection of quick ethnographical research methods [6] [7] [5]. The third important component [iii] is choosing situations from different cultural contexts like countries, companies and industrial branches. Like the thematic network “Workspace”, this too is a co-operation between a numbers of countries represented by researchers and companies from different branches and to articulate these, primarily using workshops where researchers and practitioners meet.

The other study is based on the Delphi method, developed by Rand Corporation, and is often used for predicting future trends or to explain complex courses of events [8]. It is often directed to a large number of experts that is, e.g., asked how they predict the development of certain aspect in the future. A Delphi study is mostly carried out in at least three steps. The first step, included questions directed to a large number of experts throughout Sweden, including representatives from the construction industry, real estate industry, consultants, facilities management and core business representatives and users in large organisations. The second step in our study was based on the results of the first set of open questions. The answers from step one was summarized into a large number of statements and the experts were asked to react to these statements on a four-grade scale from “I agree totally” to “I disagree totally”. The aim was to identify common conceptions among a number of experts, as for an example the relation between the identified goals of a project and the outcome of projects, and the design processes itself. It was also aimed at exploring the behaviour of different actors, and show whether there is a difference in standpoint between different actors in the process.

4. Theoretical framework

Programming and design processes aim to deliver buildings usable for the client [9] [10]. When studying these processes it is important to scrutinize both content and process. Often traditional programming and design of buildings focuses on the properties of the building itself. It focuses on the functional properties of the building and assumes that usability will follow as a causal effect of a functional design. Traditionally Swedish building research has been very successful in analysing building functionality, often with focus on housing design [11]. One of several evaluation methods related to usability is the *"The Serviceability Tool"* [12] [13] that uses the terms *performance* and *serviceability* where "Serviceability is about whether a building or facility is capable of performing as required" and "Performance means actual behaviour in service at a given moment". Another important method is the Post Occupancy Evaluation – POE – technique developed by Wolfgang Preiser [14]. POE is traditionally a technique that is used for buildings in use and thus the process outcome rather than the process itself [15].

The current trend in programming has noted the poor performance of construction projects and started to view programming and briefing as a continuous process and not something, that is being done end defined at an early stage [10]. This view also affects the role of the programmer and how that relates to the interaction between users, clients and the design and construction team [10].

Participation is also related to planning of functions and performance of buildings. A growing awareness of the importance of employee participation in organizational change and workplace design is quite new in countries like US, UK and Germany. At the same time, this has been legislated and common practice in Scandinavian countries for almost thirty years, whereas in other countries it is not even considered as relevant [16] [2].

5. The hospital design case

5.1 Örebro University Hospital

The Örebro University Hospital, USÖ, is a development-oriented medical centre located in central Örebro, a medium sized Swedish town. It has extensive basic general medical facilities and provides health care for inhabitants in the region as well as to central parts of Sweden. The European Development Centre for Radiology is located at USÖ. The O-building that is the case in this study houses two main activities, surgery and radiology, and was opened in 1997. The usable area of the hospital buildings are over 200 000 m^2. The major development of the hospital was done in 1960: s but an ongoing renovation and investment in new buildings have made USÖ one of the best-maintained hospitals in Sweden today.

5.2 The process in general

Traditionally, health care is organised in a hierarchical way. Building projects however often fall outside the ordinary relations in an organisation. The real estate unit has since early sixties had an ambitious co-operation between core business and building projects in planning and designing and have developed a culture of participatory design. They also have a long experience as a client and organiser of building projects.

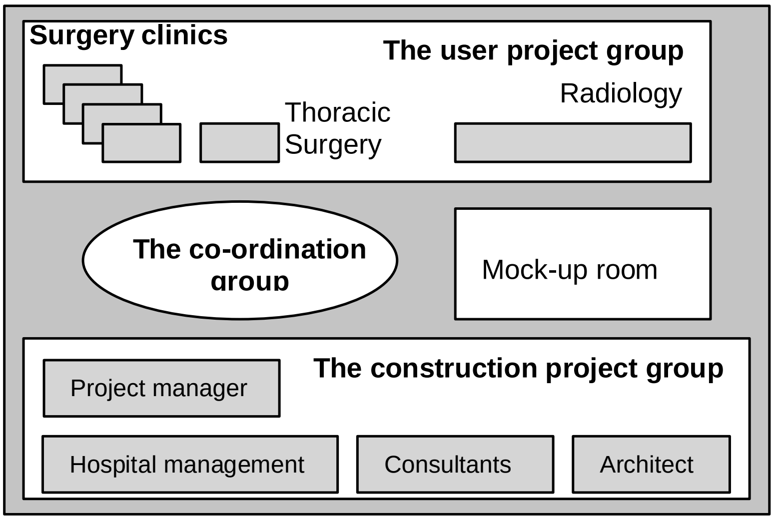

Figure1: Organisation of the design process

From the following case description of the project, we find that this participation from core business employees was very detailed and started early enough to affect strategic issues of the building project. The health care units that were affected formed design teams to develop useful solutions for their professional activities. The real estate department set up a project organisation to support the building project. Representatives for both groups met in a co-operation group to make decisions to deliver to the project steering group. The consulting architects worked closely together with the teams in both core business and the real estate department. The process to develop and design the O-building involved a large number of people. Three main groups carried out the process, thus we distinguish between the user project, the building project and the co-operation group.

Although the two parts involved in the project had the same organisation as described above, we could detect two different ways of working; a participation based model in surgery and a trust based model in radiology.

5.3 The participation based process model in surgery

In surgery, the main organisational issue was the change from an organisation where surgery was a general resource for the whole hospital and central located. In the new organisation, the surgery was divided into units that organisationally belonged to different departments (clinics). This change was however decided beforehand and was a prerequisite for the new building.

In the process, one user project was set up for each unit. However, the thoracic unit that was added to the project in 1995 did not have a user group. Due to Swedish legislation and praxis, the different unions were represented. One person responsible for continuity and strategic issues participated, mostly the head nurse for each unit. The chairperson of the department (clinic) participated as well as a representative for the assistant nurses and department of medical engineering. No representatives for services like janitors or cleaners were represented. The project group was well rooted in and chosen out of trust by the rest of the unit. They reported back at unit meetings. A construction project manager from the real estate department led the building project. This group also consisted of the architect, technical consultants and representatives from the hospital management. A co-ordination group was set up as a bridge between the user project and the building project. The head of the unit, the chairperson of the department and representatives from medical engineering participated from the user project and the architect, construction project manager and sometimes the hospital management participated from the building project. The co-ordination group made decisions regarding the development of the project. The architect also worked directly with the different units. The work done in the user project groups was presented regularly at meetings on unit level. There were large papers on the walls were people could comment on drawings and other material that was displayed. The comments were given to the architect.

5.3.1 Co-operation in design

The different surgery units in the user project carried through design activities to investigate alternative solutions and articulate the needs of the units. An important arena that all units could use was a room with a complete mock-up of an operating theatre. This was the arena where nurses, doctors and medical technicians could meet with architects and other representatives of the building project and investigate different solutions. The mock-ups were used for simulation where the degree of truthfulness to reality was extremely high and detailed.

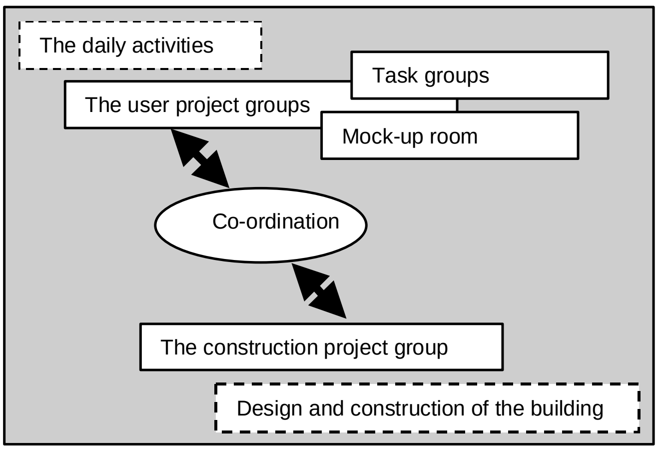

Figure2: Organisation of the design process in surgery

Most of the dialogue in the design process took place directly between individuals or groups from the user project and the building project and they often arrived at concrete conclusions and suggestions. Decisions, confirmation and policies were then forwarded to the co-ordinating group that had the formal power to take that role.

5.4 The trust based process model in radiology

In radiology, the main issue was the transition of technology. Many operators and nurses feared the new technology and the risk that their professional knowledge should be obsolete. As the more serious development in this direction took place after the briefing process for the building had started, it was also a problem for the building project. A step-by-step move of units and a thorough educational program was established to meet these problems.

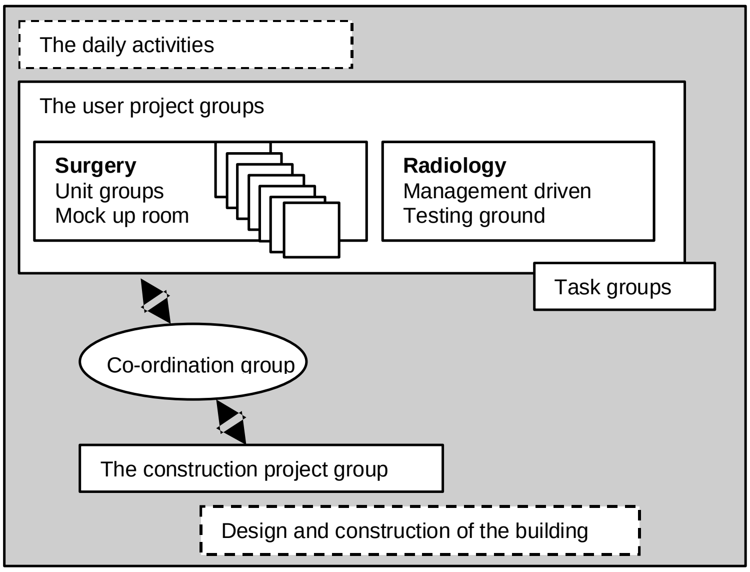

Figure 3: Co-operation in design

The process of the radiology units was somewhat different. The head of the department and the head of medical engineering were at an early stage dedicated to the idea of using new digital technology. The head of the department contacted the radiology department in the county and investigated if they were willing to convert to digital radiology and to connect to a network that could transfer digital x-ray pictures. All five radiology departments concluded that this would be a great advantage to them and agreed to participate. The idea was presented to the head of the hospital and the county politicians and got support as long as they kept the time and cost limits. The first brief for the units however suggested a mixture of traditional technology and digital technology and a step-by-step conversion to the new technology. The manufacturer of digital x-ray equipment – Philips - however took an interest in the developments and was willing to use USÖ as a testing ground for development work. This situation and the parallel development of equipment made it not feasible to use the same method of a common testing arena as was done for surgery. In this case, the development of technology was done through innovative work in all steps of the chain from Phillips laboratories to the actual radiology unit in Örebro with iterations of information and knowledge between radiology nurses, doctors and technicians on one side and engineers and researchers at Philips in the other end. The result was that USÖ became the first hospital in Sweden that totally depended on and fully utilised digital radiology technology.

5.5 Important issues in the design process

A demand from the users was operating theatres with windows and daylight. This question was raised by the building project as they thought; this could be a problem for certain processes like keyhole surgery and that they would pull the curtains down most of the time anyway. The experience from the old operating theatres, located in the dark core of a double corridor building from the seventies, was however so definite that no discussion was necessary. The users were also inspired from research in environmental psychology that stressed the importance of pleasing environment for both staff and patients. A question related to this was access to outdoor terraces. This was a trickier question, as it was easy to advocate for the hygienic risks of going outdoors when working in a surgical unit. No real arguments came up that could justify outdoor terraces, but today there are terraces in the building to the pleasure of the staff. However, everyone realized that it was a calculated risk and it is now used with a strong awareness that the hygienic regulations must be followed rigorously. These issues are examples on what impact the participation process actually had on the building.

6. Discussion

Based on the USÖ case study and the two approaches it is shown that there are several ways of achieving a usable solution that satisfies the client. In the light of the Delphi study this is important as that study concludes that programming might not be sufficient. In the USÖ case, e.g., the mock-up room was used as a complement. However, as we found, the two approaches have different characteristics; participation requires a large amount of time, and the trust-based approach requires maturity from the organization in order to be possible. Studying the process that took part in the O-building case, we can clearly see the importance of participation for development of a usable building. By participation in the mock-up room work functions could be tested for real and not only agreed upon based on a functional specification. The gap between definition of function and real use was thus bridged. In radiology, the relationship between function and usability developed differently. Based on the trust for the head of the radiology department and technical manager they were allowed to develop a radiology department based on digital technique. If these persons had not had the trust of the staff, the new solution would have faced fierce resistance by staff. The trust allowed for an efficient process were few actors pushed the process and the staff participated only in meetings and were not actively involved until the new radiology department was about to get staffed and completed. The trust even allowed for drastic changes like the change of technology in the radiology department. An overall trust related aspect is also that the county has a long-term experience from participative building design processes and thus the staff, in both surgery and radiology, knew that involvement was a part of the process - it was never something they had to fight for.

Looking back at the USÖ study we find that the programming and the design phase were articulated. The organization was well prepared to manage participation and had a structured way via the co-ordination group to stay in contact with the construction project. This also allowed the users and the construction project to focus on their prime issue and direct discussions to the co-ordination group with its task of pushing the project forward. These processes were also given time as the county have incorporated an iterative and participative process suitable also to the, partly, political decision processes in public health care. This enabled those who were not directly involved to at one stage or another take a look into the project without it having to be organized as formal participation. Communication and information is essential as well in this process.

If we compare these findings with the findings from the Delphi study we find that the difficulties noted regarding un-articulated processes and lack of consistency in programming was managed through the USÖ approach that incorporated participation, openness and that the process was given time. The aspect of having time to develop and explore is, we conclude, due to the kind of decision process associated with the use of public funding. In this case we regard this as a positive effect that benefited the development in the USÖ case, depending on outset it might not. It must also be noted that the time in the USÖ case was utilized for establishing a design, the time given was used instead of passed.

7. Conclusion and further research

The experience from these two studies is that a well managed programming and design process results in a usable building. However with this somewhat obvious statement it is important to question what lesson can be learnt. From a Scandinavian perspective it is interesting that a trust-based process worked just as well, or better, than a participative one. As noted in the CIB TG51 group on usability the cultural and contextual aspects are discussed and it seems that the situation at USÖ enabled such a process to be performed. For future planning processes it is relevant to study what mechanisms that makes a trust-based approach feasible, and if it can be more efficient than a participative based one.

Another finding that raises questions is the fact that the USÖ was "given" time, it did not have to "take" time. This, we conclude, is due to the structure of decision processes regarding facilities within public health care, and in the USÖ case the stability of the organization, and led to a process where both the trust-based and participative-based process could develop. However, in times of outsourcing and change of view on clients and suppliers in public services, the question of time allocation might matter. A further study would be needed to study what resources are needed to outsource facility related services and how this relates to both client and user experience of quality.

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Changing Client Role in Emerging Construction Procurement

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Abstract

The client in the construction sector has a pivotal role in the successful delivery of projects. The role performed by clients in this regards has been undergoing transformation over the past two decades in response to demands for improvement and innovation to achieve better value for all the stakeholders involved in the delivery of projects. A review of some of the principal models for managing the procurement of projects provides an insight on the nature of transformation in the role performed by clients. The subsequent sections of this paper provide an outline of four procurement models that provide a context for exploring the change in role performed by the client. The subsequent analysis evaluates the role and requirements placed on the client by the criteria of managerial capability. The analysis shows a growing transition from a passive to an active role for clients in the management of the procurement process.

Keywords: construction, client, procurement, projects, management

1. Introduction

The role of the client in construction projects has been going through a transition over the last two decades (Cawthra, 1991; Technology Foresight, 1995; DTI, 2002). A significant outcome from this transition is a shift in the power-balance in favour of the client (Ling and Lau, 2002; Liauw et al., 2003). In attendance to the shift in power balance is a change in the nature and capability for managing the delivery of projects that clients are required to display in. The conventional approach for the delivery of construction products relies on methods that are rooted in the separation of responsibility and production activity for the different phases or tasks that make up the project (Anderson and Tucker, 1994). This naturally creates interface constraints as well as a limitation in optimising the functional, economy and production of the constructed product. Contributing to the interface constraints is the juxtaposing of different organisation systems and cultures, which often impact negatively on the productivity of the project. The solution to minimising the interface and optimisation constraints is considered to be in the adoption of a process orientation for all the activities connected with the delivery of construction products

(Cooper, 1994; Cooper et al., 1998). The process approach emphasises the integration of the contribution rather than the task output from each of the different stakeholders. McCaffer and Edum-Fotwe (2003) provide an illustration for considering construction from such a process perspective and identify interface between principal phases as key constraint to attaining optimum efficiency. The consideration of construction projects as production process induces a re-alignment of roles performed by the different stakeholders. The pivotal role played the client in conventional projects makes any such change in their role pertinent to successful delivery of future projects. To provide some boundaries to the nature of change in client role four procurement models are explored for the nature and role required of the client. Two of the procurement models are extensively employed in construction, and the other two are emerging alternatives that are finding increasing utilisation within the sector. The analysis shows a potential trend of a transition from a passive to an active role for clients in the management and technical requirements they have to address in the procurement process.

2. Construction Procurement Models

The subsequent sections of this paper provide an outline of the procurements models that are employed to provide a context on the way the management of procurement has been changing with regard to the role of the client. These comprise two established models of procurement and two emerging ones. The two established models which are designated in this paper as traditional are drawn from engineering construction, and building sub-sectors, while the emerging models reflect the stage-gate process approach, and the use of framework arrangements.

2.1 Traditional models

2.1.1 Engineering construction model (civil works)

The delivery of construction projects in this model is represented as a six phase linear process as shown in Figure 1.

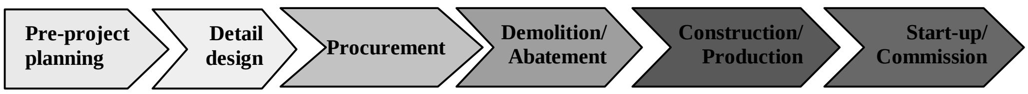

Figure 1. High level process outline for engineering construction

The main benefit of this model is to provide clarity in the way the project delivery is structured, and as a consequence, lead to the identification of potential difficulties early enough to mitigate incidences of low productivity. Table 1 depicts the six phases with typical participants in each phase. This model is usually not applied to infrastructure and building projects procured in a traditional competitive tender or the increasingly popular design and build arrangements as the process assumes an internal client and supplier.

Table 1: Role of parties in engineering construction model for projects

Project Phase	Pre-Project Planning	Detail Design	Procurement	Demolition /Abatement	Construction /Production	Start-up/ Commission
ypical articipants	Client representative Planning Consultants Constructability Consultant Alliance / Partner	Client's representative Design Contractor Constructability Expert Alliance / Partner	Client representative Design Contractor Alliance / Partner	Client representative General Contractor Demolition Contractor Remediation / Abatement Contractor	Client representative Design Contractor (Inspection) Construction Contractor & subs	Client representative Design Contractor Construction Contractor Training Consultant Equipment Suppliers

However, the coverage of a start-up/ commission phase makes this model of delivering construction suitable for projects procured by turnkey arrangement and private finance initiative as well as alliance projects. While the engineering construction project model presents a clear involvement by the client or its representative, in reality that role is often passive, as the key activities undertaken reflect approvals and control.

2.1.2 RIBA Plan of Works (building works)

The RIBA Plan of Work is a robust procurement management approach which describes the activities from appraising the client's requirements through to post construction (Phillips, 2000). The stages are also used in the appointing documents to help identify the architect's services. This model of is predominantly applied for schemes that are classified as architectural in outlook. These schemes cover simple private dwelling houses through public sector offices to commercial accommodation such as hotel facilities. The key stages of the plan are outlined below in Table 2. The RIBA plan of works assumes a linear progression from one stage to the subsequent one. Thus, all design inputs are deemed to have been completed when construction commences. This, clearly, does not happen in practice, as several design changes are known to transpire during the construction stage, an indication of the incomplete input for the preceding design stages. The role of the client is equally assumed as passive in conformity with the notion that the client is hardly informed, and the consultant/designer knows what the client should want. The onus is therefore, on the specialist to effectively elicit the requirements of the client and formulate them into a design solution.

2.2 Transition in procurement

The need to increase efficiency within construction has occupied the attention of several of its stakeholders over the years (Latham, 1994; Egan, 1998). The inefficiencies identified with projects in the sector have been associated with a lack of a process approach by Egan (1998, 2002).

The emergence of knowledge as a prime value in the delivery of design has elevated the role technology could play to ensure the efficient management of knowledge within organisations.

Table 2: RIBA work stages for project development

	WORK STAGE	WORK STAGE DESCRIPTOR
A	**Appraisal**	Identification of Client's requirements and possible constraints on development. Preparation of studies to enable the Client to decide whether to proceed and to select probable procurement method.
B	**Strategic Briefing**	Preparation of Strategic Brief by, or on behalf of, the Client confirming key requirements and constraints. Identification of procedures, organisational structure and range of Consultants and others to be engaged for the Project. [*Identifies the Strategic Brief as CIB Guide which becomes the clear responsibility of the Client*]
C	**Outline proposals**	Commence development of Strategic Brief into full Project Brief. Preparation of Outline Proposals and estimate of cost. Review of procurement route.
D	**Detailed proposals**	Complete development of the Project Brief. Preparation of Detailed Proposals. Application for full Development Control approval.
E	**Final proposals**	Preparation of final proposals for the Project sufficient for co-ordination of all components and elements of the Project.
F	**Production information**	F1: Preparation of production information in sufficient detail to enable a tender or tenders to be obtained. Application for statutory approvals. F2: Preparation of further production information under the building contract. [*Now in two parts, F1 - the production information sufficient to obtain tenders and F2 - the balance required under the building contract to complete the information for construction*]
G	**Tender documentation**	Preparation and collation of tender documentation in sufficient detail to enable a tender or tenders to be obtained for the construction of the Project. [*Solely concerned with the documentation required for tenders. Particularly useful with D+B or management contracts*]
H	**Tender action**	Identification and evaluation of potential Contractors and/or Specialists for the construction of the Project. Obtaining and appraising tenders and submission of recommendations to the Client.
J	**Mobilisation**	Letting the building contract, appointing the contractor. Issuing of production information to the contractor. Arranging site handover to the contractor.
K	**Construction to Practical Completion**	Administration of the building contract up to and including practical completion. Provision to Contractor of further Information as and when reasonably required.
L	**After Practical Completion**	Administration of the building contract after practical completion. Making final inspections and settling the final account. [*Clearly separated from the construction phase*]

Knowledge management and sharing can be difficult without clear processes to capture and contain both what is already known, and the new knowledge and skills that are acquired on a daily basis (Lazarus, 2001; Edum-Fotwe, et al., 2004). The adoption of the process approach is equally seen as presenting construction with an opportunity for transforming its delivery of products by adopting innovations from manufacturing. This perspective has been championed in the UK by the *construction panel* of the Innovative Manufacturing Initiative (IMI). The development of a Generic Design and Construction Process Protocol as a direct response to the IMI construction theme has opened up the opportunity for a wider deployment of the process approach to procure construction (Cooper et al., 1998).

2.3 Emerging procurement options

A number of variants of existing models for managing the procurement of construction as well as alternative ones have been employed by different clients and projects. This section addresses the alternative models and comprises the process protocol and framework agreements.

2.3.1 Construction Process Protocol

The construction process protocol is based on the RIBA plan of works and provides a phase process to represent the delivery of construction projects. The protocol provides a departure from the linear approach to modelling the delivery of projects by viewing the interaction of activities within the process in a two-dimensional stage gate framework. Using manufacturing principles as a reference point, a framework of common definitions, documents and procedures were developed to help construction project participants work together seamlessly (Cooper, 1994). The design and construction process is mapped into eight sub-processes; Development, Project, Resource, Design, Production, Facilities, Health Safety and Environment, Statutory and Legal, and Process Management; four broad stages, as in Pre-Project, Pre-Construction, Construction and Post-Construction; and ten phases (Cooper et al., 1998).

The construction process protocol represents for the construction sector, the main generic design and construction process protocol (GDCPP) for the comprehensive management of projects. The introduction of the two-dimensional perspective by the process protocol for viewing the interaction of the activities in the delivery of construction presents an opportunity for a more effective project management. This can be very useful in achieving the same level of detail for the whole process. The main principles of the GDCPP are summarised below.

Whole Project View: This ensures that all the issues are considered from both a business and a technical point of view as well as ensuring informed decision making at the 'front-end' of the design and construction development process.

Progressive Design Fixity: The benefit of this approach is fundamentally the progressive fixing of design information throughout the Process, allowing for increased predictability of construction works.

A Consistent Process: The generic properties of the Process Protocol allow a consistent application of the Phase Review Process irrespective of the project in hand. This together with the adoption of a standard approach to performance measurement, evaluation and control, will facilitate the process of continual improvement in design and construction.

Stakeholder Involvement / Teamwork: The pro-active allocation of resources to Phases through a 'stakeholder' view should ensure that appropriate participants (from each of the key functions) are consulted earlier in the Process than is traditionally the case.

Co-ordination: The need for effective co-ordination between the project team members is paramount and ensures the correct application of the Process Protocol to the project.

Feedback: The Phase Review Process facilitates a means by which project experiences can be recorded, updated and used throughout the Process, thereby informing later Phases and future projects.

The process orientation presents clients as well as other participants with an overall picture of the project. This provides better opportunity for aligning the different operational regimes and task objectives for the various project participants. The implied assumption underlying the process approach is that client actively engages all the other stakeholders for all the phases of the project.

2.3.2 Framework Agreements

Framework agreements are procurement arrangements made with a single supplier or a number of suppliers with a view to achieving significant savings in cost and eliminate interface constraints to both the client and suppliers. The agreement operates as a continuous contract for the supply of goods and services to the project. There is no requirement for constant re-tendering at call-off stage as long as the contract conditions are unchanged for each project. This presents opportunities for substantial gains from continuous improvement by eliminating the transaction cost associated with repeat tendering. Where contract terms are changed, mini-competitions within the framework will need to take place. Clients may have more than one framework supplier in place for different requirements. However, the resource implications for the client should be borne in mind when deciding whether to appoint more than one framework supplier under a single framework agreement. The use of framework agreements lends themselves to the procurement of projects under the *prime contracting* and *design & builds* routes. They can also be appropriate for maintenance requirements of major infrastructure and facilities such as roads and hospitals. It should be noted that there is no commitment under a framework agreement for either party to undertake any business until the first contract is '*called off*'. Framework agreements are not usually contracts in their own right as defined in EU Procurement Directives, but agreements to do business under specific terms. Within the framework a contract (*call-off*) is let for each project. This initial call-off is no more complex than placing an order because the price structure and conditions of contract are fixed.

The client, within a framework agreement is required to engage actively with all suppliers on a continuous basis. This includes providing the framework suppliers with the *best* information available on annual forecast of anticipated demand, and standardising output specification to improve cost, predictability and maintainability.

3. Analysis of Client Role in Changing Procurement Regimes

The traditional and emerging models of procurement present various levels of involvement by the client in the delivery of construction. To understand the requirements placed on the client within the two categories of procurement models, a simple listing of criteria of three project principals were investigated in two areas, *managerial* and *technical* role. The other two project principals are the project sponsor and the project manager. This analysis within this paper is focused on the managerial role. The roles of the two other principals (the project sponsor and project manager) provide representations of the technical and risk requirements that are managed on projects. A comparative evaluation of the role of the client with reference to these roles therefore, provides a rational basis for judging nature of change in role by the client. The managerial roles and requirements were analysed over ten factors as follows: *Decision making, Effective critique, Communication, Motivation and drive, Team building, Facilitation, Interviewing, Negotiation skills, Assertiveness* and *Objective setting*. These were derived from earlier work on managerial roles in construction (Songer et al., 2004; Vossoughi, 1998; Pugh, 1991).

Figure 3 presents the analysed role of the client vis-à-vis the role played by the other two principals for the managerial attributes required of them in their functions they perform. These have been organised as essential and desirable criteria. Desirable criteria are capabilities that the client or the principal is not required to exercise to perform their role, but may assist with the performance of other related activities. The essential criteria however, are a must, as they form the basis of the involvement of the client or principal in the project process. The role of the client under the traditional procurement regime had focused on four key functions as essential requirements. These are *decision making, communication, negotiation skills,* and *objective setting*. This is naturally so as the client traditionally relies on the expert inputs from the other two principals to manage the project. Roles such as decision-making, communication, and objective setting are pertinent to the establishing the expectations of the client, and as such cannot be delegated to the other principals. It is easy to appreciate that need for the client to clearly and fully define their needs and expectations in the brief, since late changes of mind can prove expensive both in terms of timescale and cost. Equally, the need for effective negotiation skills is essential for the engagement of the principals in the first instance. The role of the client in the emerging procurement model elevates the requirements demanded of the client from the traditional models to include *providing effective critique, motivation and drive, team building, facilitation, interviewing*, and *assertiveness*. These requirements clearly call for a hands-on approach to managing the whole procurement process for delivering construction projects. It also implies a display of leadership and management skills to ensure a best practice performance by the client. Clearly it demonstrates that the drive for value in delivering construction projects places equal responsibility on the client as it does for the other principals in managing the procurement process. This equal responsibility for example translates in practice to a situation whereby clients are required to display astuteness in ensuring that the right team is appointed (either collectively or individually) to provide advice and to represent the client's interests as well as an active role in the establishment and working of task delivery teams.

MANAGEMENT CAPABILITY - Traditional						
	Project Owner		**Project Sponsor**		**Project Manager**	
Attribute	**Desirable**	**Essential**	**Desirable**	**Essential**	**Desirable**	**Essential**
Decision making						
Effective critique						
Communication						
Motivation						
Team building						
Facilitation						
Interviewing						
Negotiation						
Assertiveness						
Objective setting						

MANAGEMENT CAPABILITY - Emerging						
	Project Owner		**Project Sponsor**		**Project Manager**	
Attribute	**Desirable**	**Essential**	**Desirable**	**Essential**	**Desirable**	**Essential**
Decision-making						
Effective critique						
Communication						
Motivation						
Team building						
Facilitation						
Interviewing						
Negotiation skills						
Assertiveness						
Objective setting						

Figure 3: Changing client managerial requirements under different procurement regimes

It also means that the client is required to exercise more than just a desirable know-how of both technical and managerial roles which until the advent of the emerging procurement models had been the sole preserve of the professionals who act as principals. Furthermore, it calls for regular monitoring of the entire development process throughout all of its stages directly by the client, including responding to the reports of gateway reviews carried out at key approval points in the process and carrying out a post project evaluation of the process on completion.

Clearly, the deployment of manufacturing oriented methods of procurement is changing the role of the construction client from a passive participant in the project to an active one. Not only is the client owner of the completed product, but the nature of the procurement is demanding a situation where clients take ownership of the whole procurement process.

4. Conclusion

The last decade has seen an increasing emphasis on the client's role in ensuring that products and services within the construction sector meet defined needs fully and at the best possible value. This is particularly the case for the UK Government's role as a client for construction projects. The use of more business and manufacturing oriented processes for delivering construction is changing the role of the client in projects. An outcome of these changes is the sector's migration toward a re-defined procurement models and a re-allocation and alignment of the core functions and role for the different project stakeholders. The role performed by clients in this regards has been undergoing transformation over the past two decades in response to demands for improvement and innovation to achieve better value for all the stakeholders involved in the delivery of projects. In the paper, a review of some of the principal models for managing the procurement of projects has been presented. These provide an insight on the nature of transformation in the role performed by clients and gives an indication of an extended role for the client. The subsequent analysis evaluates the role and requirements placed on the client from a managerial perspective. The analysis shows a growing transition from a passive to an active role for clients in the management of the procurement process.

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Improving the Delivery of Social Housing in UK through Strategic Partnering– Using the Amphion Initiative as a case study

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Abstract

Amphion Consortium was formed as an initiative in implementing the Egan agenda (1998) which championed the use of long term partnering as a mechanism for achieving radical change in the construction industry. This project used this unique opportunity to develop, monitor and record the performance of 28 housing development projects which accounts for approximately 500 house units. Relevant KPIs, benchmarks and a robust data collection and site monitoring system were developed by the research team in conjunction with the RSLs, client agent and the main contractor following consultation with representatives from the Housing Corporation, DTI and the Construction Best Practice Programme. Detailed interviews with key project personnel, examination of site meeting notes and general feed back reviews were undertaken to identify good and bad practices associated with each project and with the Amphion experiment in general. The turbulent path followed by Amphion and their contractors illustrate how the strategic roles played by key players in the housing industry have a substantial effect on the construction process. Good communication, effective co-ordination and long term partnering which lead to continuous improvement of services and products emerge as some of the key drivers for the successful delivery of quality social housing which meet both the time and cost targets. The key players in the team including the RSLs, the contractor, the consultants and professionals have to be committed to the partnering process to make it successful.

Key Words: Social Housing, Amphion, Partnering, Key Performance Indicators (KPIs), Benchmarking

1. The background to the Amphion programme

The 'Rethinking Construction' report (1998) called for a radical review of the UK construction industry and recommended a number of measures, including long term partnering as a method of improving the performance of UK house building. ‘Partnering is a management approach used by two or more organisations to achieve specific business objectives by maximising the effectiveness of each participant’s resources. It requires that the parties work together in an open and trusting relationship based on mutual objectives, an agreed method of problem resolution and an active search for continuous measurable improvement'[1]. Partnering can be either project specific, where the arrangement is for the duration of an individual project; strategic or long-term where the arrangement is for a specified period of time, normally covering a number of projects. Strategic or long-term partnering usually provides greater opportunity for improvement [2].

While Egan was reviewing the efficiency of the UK construction industry, a number of housing associations were reviewing the way they procured their housing stock and considered their new building stock was both expensive to build, and maintain. The defects that were still apparent, and the waste produced on site, did not seem consistent with a sustainable method of construction. As a consequence of this review, a small number of housing associations concluded that they needed to systematically change their procurement methods if they were to improve both the quality and cost efficiency of their new build programmes [3]. The required demand was beyond the scope of these housing associations alone and in order to generate more demand and change the procurement methods, the Amphion consortium was formed with 20 housing association members, who collectively agreed to procure 2000 pre-fabricated houses over a four-year period. Once the demand had been established, Amphion set about instigating change in their procurement processes. The key changes that were envisaged included the;

- development of a partnering arrangement with one preferred house builder
- development of a factory based house production facility
- establishment of key performance indicators (KPIs) by which any changes could be monitored
- setting up and managing of whole house building supply chain.

2. The Amphion Programme

Amphion promoted Egan principles by introducing lean production methods into house construction using modern timber technologies to produce housing in a factory setting [4]. One of the main objectives of the project was to promote volume (450 units in year 1, rising to 500 and 550 units in years 2 and 3) and continuity of production for the development of timber framed dwellings. The consortium set themselves the following targets to continue delivering improvements in quality, cost, time and customer satisfaction. In long term, they planned to:

- Achieve a demanding set of targets for incremental improvement in technology with the objective that by year 4 at least 75% of the superstructure will be factory produced.
- Further enhance training, not only for the site and factory operatives constructing and assembling the units, but also training for RSL staff so that they can be effective clients.
- Explore the possibility of external accreditation.
- Achieve significant reductions in construction periods and costs. Fewer defects, fewer site accidents and increasing customer satisfaction.

- Produce different templates to facilitate high density schemes, small site schemes and projects such as nursing homes and sheltered housing.
- Achieve growth through land acquisition.

3. The Research Project

The research project was to use the opportunity offered by the Amphion consortium programme of new build homes to develop, monitor and record the cause/effect relationships when introducing the change management tools used for Egan Compliance. The main aim of the project was to set, monitor and compare the KPIs and related benchmarks to be over and above the national and industry averages. Within this aim, the objectives of the projects were:

- To obtain agreement amongst all interested parties as to what benchmarks and KPIs need to be monitored to ensure Egan compliance;
- To develop a simple, robust method for on-site monitoring of KPI data;
- To calibrate the benchmarks and KPIs;
- To map the cause and effect relationships within the change programme.

The project was funded by the Engineering and Physical Sciences Research Council and the Department of Trade and Industry through the Link MCNS Programme. The main benefit of the project can be stated as, ‘the identification of best practice guidance and the development of simple, robust management information tools that will allow all Registered Social Landlords (RSLs) the facilities to drive improvements in the procurement of their new housing provision’.

The first stage of the research was the development of a series of performance indicators that could be used to monitor any changes that resulted from the new procurement approach. The project built on the ideas presented in the Egan report in which 7 key indicators were identified and extended to other KPIs which were relevant and specific to RSLs as well as the contractor. These were developed in consultation with the relevant team members with the help of workshops, brain storming sessions and many review meetings and included survey methodologies to obtain both quantitative and qualitative data on current new build performances. In all, about 50 KPIs, related benchmarks (where appropriate) and a robust data collection and site monitoring system were developed by the research team in conjunction with the RSLs, client and the main contractor following consultation with representatives from the Housing Corporation, DTI and the Construction Best Practice Programme. Specific metrics were developed under five thematic areas including Sustainability, End User Enjoyment, Project Performance, Cultural Performance and Respect for People. Following an initial pilot study these were reduced to 34 metrics under six themes and exceeded those required by national monitoring programmes. The effectiveness of the partnering process was monitored as one of the themes.

4. The Partnering Process

Partnering is a collaborative approach that benefits all parties involved, while focusing on the needs of the customer. In the right circumstances the rewards can be substantial. To gain maximum benefit it is essential to extend the process through the supply chain in order to harness the specialist expertise of subcontractors, material suppliers and manufacturers.

4.1 Partnering Indicators

In order to evaluate the partnering criteria within the Amphion consortium, the following indicators were monitored.

Table1: Partnering Indicators that were monitored

Clients team and its response	Time to respond to instructions & urgent matters
Clients information	Information that was provided regarding the nature of site etc. which will make the contractors tasks easy.
Communication & Co-ordination	• Consultations with contractor • Contractor involvement stage • The number of qualifications (financial) presented by contractor
PPC 2000 conditions	Pre-contract matrix
Contractors cash flow	Time and payments • Time from possession to first payment • Total number of days late from issue of certificate to payment
Partnering ethos	Volume and continuity of work (% of Amphion work/ Total work load)
External professionals	• Planning approvals • Time taken beyond programme • Auditing of professional work (Number of errors / drawing revisions

Amphion Consortium was set up to partner with one preferred contractor as well as selected suppliers in a supply chain. Due to the market forces that were beyond control of any team member, the contractor changed a number of times over a very short period of time and had adverse consequences over the whole process. The trust and confidence building process of the team was disrupted and many attempts made to get the supply chain partnering process were unsuccessful.

Eventhough demand was a key issue to be addressed, the consortium did not reach their target for the selected time period. This was mainly due to problems experienced by the contractor, land supply, the delays associated with section 106 projects and some unsuccessful capital bids to the Housing Corporation. Many shortcomings were identified:

- Factory production was initially working below capacity creating cost premiums at early stages with target cost reductions not achieved.

- Small infill sites were initially brought forward for inclusion in the programme when the product most suited larger sites with predominantly terraced and semi-detached houses.
- Development planning difficulties, including the nature and suitability of Section 106 agreements, could often delay the bringing forward of units in line with the plan.
- The technology was slow to advance and off-site manufacturing only reached a level of 35% opposed to the 75% targeted for the programme.
- Strategic changes in the partnership meant that quality of some projects was poor
- Value chains of the various partners were not sufficiently aligned leading to problems with delivering partnership benefits as intended [5].

It is fair to state that the Amphion partnering process did not get a good chance to be effective in the unforeseen short term contractor changes. Even though, many positive and negative criteria which could benefit future projects were identified in the process.

Table 2: Positive and negative criteria identified in the process

Positive Criteria	Negative Criteria
Contractor's early involvement and early discussions were beneficial.	The consortium structure, the member's involvement and commitment was not complete.
Attempts were made to increase the awareness of Amphion aims and objectives on site and make all staff aware of the Amphion process.	This process did not take off as envisaged and most staff members were unaware of the process that was unique to Amphion.
Domain of supply chain partners identified and an attempt made to get the supply chain effective.	This was not progressed as envisaged.
To improve Co-ordination and Communication policy groups were set up for each major issue.	The reporting process was not efficient and not in place for a while. The necessary reports and management charts not prepared on time.
Working group established to progress to Client Charter status	The number of policy groups reduced due to management difficulties
Analysis and maintaining an open book at Deptford	Cash flow problems.
PPC 2000- A simplified Partnering Agreement issued for use with the sub contracts.	New Partnering agreement has to be made after year 1 review. Increased use of amended contracts due to complex nature of schemes. Early execution of PPC 2000 contract documents - culture change required for by all parties – client resistance still being experienced in some cases.
Information for life cycle costing exercise coming through in the latter part of the project.	Lack of information for life cycle costing exercise at the beginning of the projects.
Identification of additional contractor partner based on operating location, land bank, social housing experience, and commitment to off site manufacturing and partnering.	Decision made to pursue possibilities with other suppliers at a local level.
Amphion becoming an off site manufacturing forum	Possibilities of terminating the consortium
The Amphion Design brief has been reviewed by a working group to include best practice and lessons learnt to date.	Debates about who Amphion is partnering with, firstly timber framed supplier and secondly main contractor.
Risk register was viewed as a shared tool for improving the accuracy for pricing. Risk was to be allocated to the party best able to deal with them and priced accordingly.	Problems with new partnering agreement and procurement agreements with changing contractors. Concerns continue to exist on quality of service from non-Amphion Architects
Post Contract- The establishment of a consistent team and employment of staff for on site activities. A post contract site diary to be kept and circulated with the view that the lessons learnt will feed into future contracts of this type.	Pre-contract process was unduly demanding in terms of time which resulted in uncertainties over programme and a grater number of tender qualifications than was desirable. More to be made of the pre-contract value engineering and the need for a common standard of information requirements for clients. The pre-contract requirements put pressure on timing - potentially at the expenses of accuracy to be amended or deleted.

5. Lessons learnt

Amphion has now reached the final year of the partnering process. The group had set up policy groups who met regularly to look at issues such as technology and innovation, benchmarking and partnering the supply chain. As the lessons learned by all those involved with Amphion begin to work their way through the system, significant improvements in performance can be observed and enable the consortium to continually value engineer the process and seek continuous improvement. Fig. [1] illustrates improvements in benchmarks scores for Projects 10, 11 & 12 which started on site two years after Project 1.

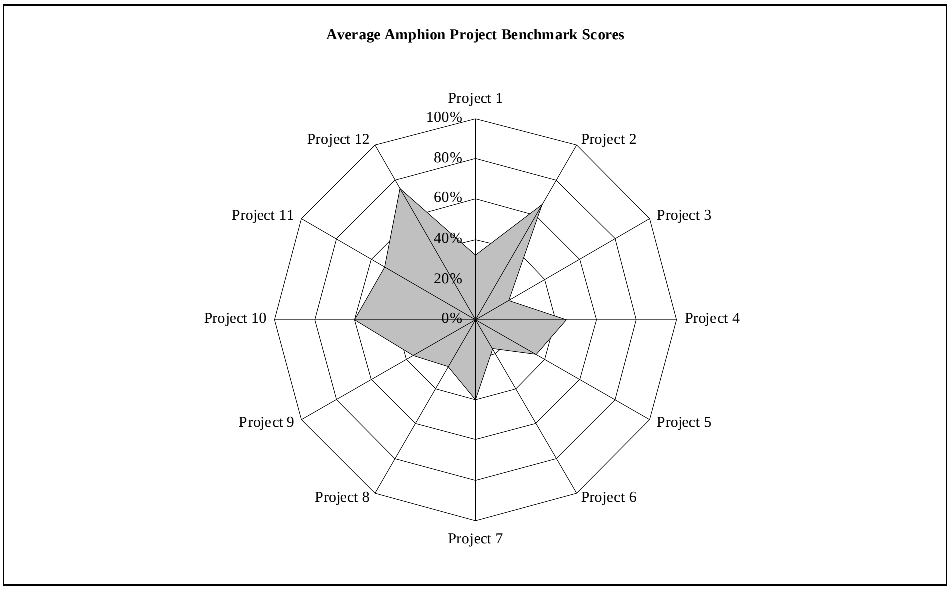

Figure 1: Average Amphion Project Benchmark Scores

The relationship with the contractor provides some key issues which can be beneficial to the industry as a whole. It was easy to see that in projects where the contractor got involved at an early stage many problems were solved before the project went on site for construction, thus saving on valuable construction cost and time. The more information that was provided to the contractor by the client at preliminary stages made it possible for the contractor to make more realistic feasibility sums regarding the project, allowing for problems in site to be dealt with speed and a minimum cost.

The importance of partnering the whole supply chain also emerged as a key issue in the process. If the contractor cannot co-ordinate his sub-contractors and suppliers, the whole partnering process ground to a halt affecting the cash flow of the contractor and the whole construction process. There were many good and bad practice issues that were identified by RSLs as important from the Amphion experience. The good practice issues were; increased health and safety measures, reducing the environmental impact, achieving the sustainability targets while the bad practice issues include defects not being attended on time, lack of communication and co-ordination and complicating the construction process by the introduction of many middle agents.

The main lessons that can be learnt from Amphion are not only from the data that was collected but by the interviews which gave an insight to the way that the key personnel felt about the whole partnering process. Many short comings in terms of communications between parties, distributing the knowledge gained by managers among the site and factory personnel, discrepancies in key management decisions among parties were commonly sited as drawbacks. In most cases decisions that were important to the process was not discussed or shared with the main personnel on site agents resulting in resentment among the lower ranked staff. From the workshops it was concluded that a new initiative like Amphion need a good backup programme in terms of technical help, assistance and a quick method of problem solving rather than a long drawn process involving many hierarchical management systems. A central data base where information is stored and easily accessible to all concerned is also of crucial value.

In general, the study illustrates how the availability of land (which was a key issue in the changes in the contractor's profile) and the strategic roles played by key players in the housing industry have a substantial effect on the partnering process. Communication, co-ordination and long term partnering which lead to continuous improvement of services and products emerge as some of the key drivers for the successful delivery of quality social housing which meet both the time and cost targets. The key players in the team including the RSLs, the contractor and the consultants and professionals have to be committed the partnering process. The lessons learnt from this project will benefit other RSLs, Government housing authorities, and industry professionals as they seek to address the challenge of achieving best practice and continuous improvements in new social housing development.

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Management System for A Virtual Construction Management Services Company (VCMSC)

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Abstract

A virtual construction management services company (VCMSC) is herein defined as a dynamic competitive network of collaborating special system contractors that reconfigure around a leading member whenever an opportunity arises. A single leading member guides this virtual network both on a short and long term basis, members can be geographically dispersed firms, organizational units, teams, or individuals. Each member concentrates on those parts of the value chain with which it achieves the maximum added value. A new management system of a VCMSC consists of six subsystems and related principles which together enable the virtual management of (i) project owner relations, (ii) project offerings and bidding, (iii) project design and engineering, (iv) project procurement, (v) construction, execution, and control, and (vi) network nurturing. In the near future, an empirical inquiry and a testing of the subsystems will take place to validate the suggested VCMSC model, overall, in the context of the building market in Finland.

Keywords: Construction management, management system, virtual management, virtual organization

1. Introduction

The paper is part of the ongoing study on **developing new concepts and systems** for managing a virtual construction-related company. The study is carried out in the unit of Construction Economics and Management (TKK/CEM) at the Helsinki University of Technology. Prior this paper, we have conceptualized the virtuality to a modest extent in the focal context [1], [2].

Our rationale for focusing on construction management (CM) services company is justified by referring to **the two representative accounts of CM forms** in the contexts of the USA and Finland as follows. In the USA, The organizational make-up of a CM firm is unique in the construction industry. Neither a contractor nor an architect/engineer (A/E) firm can match its functions or personnel. CM practice has substantiated a fact that CM firms must be multi-discipline organizations compared to traditional construction industry practitioners such as architects, engineers and general contractors [3]. There are two forms of **CM consulting** and **CM**

contracting also in Finland. A CM consultant acts as an agent (as in the case in CM Agency form in the USA). All the procurement packages will be bought from the market on a competitive basis. A client (an owner) enters directly into the contractual relationships with each of the subcontractors and suppliers. Design and procurement are performed concurrently (Figure 1). In turn, **a CM contractor** is responsible for PM, site management, site facilities and services, and construction works. A client has only one contract with this CM contractor. In turn, a CM contractor acts like a general contractor. Alongside, a client also relies on a separate agent who strengthens a client's organization and construction knowledge [4].

In addition, we align with the key contributions within virtual organization literature. A virtual organization (VO) as an evolving model is rooted in the paradigm of network organizations [5], [6], [7]. It resembles a dynamic network that facilitates the discovery and the configuration of core competencies in a value chain, which in theory leads to an optimal value creation process [8]. **A virtual company (VC)** is considered a purposeful system composed of a set of interrelated elements, i.e. actors, resources, and activities [8]. It has the ability to alter a value creation process [9] through a concept of switching [10]. The essence of VCs is meta-management of goal-oriented activity. In turn, dynamics within **a virtual construction management services company (VCMSC)** involves a 3-stage process of formation, operation, and termination, which explains how a structure comes about and how its management evolves over time. Initially, we defined a VCMSC in such a way as to be capable of adjusting to changes in its environment and renewing itself by designing and implementing new CM service processes based on the three constructs: IT-enabled network, virtual operations, and customer value [11]. A working mechanism was drafted in light of a theoretical concept consisting of three transitional layers that represent the organizational structure elements, while interactions between these layers represent the dynamic management elements [2].

The aim of this paper is to introduce the initial management system for a VCMSC. Our focus is on management, not on information technology (IT) as many virtuality-related scholars do. The sub-aims include (a) to define the principles for the virtualization of a traditional building contractor, (b) to design a management system of a VCMSC as a whole, and (c) to design its six sub-systems for managing (i) project owner relations, (ii) project offerings and bidding, (iii) project design and engineering, (iv) networked project procurement, (v) construction, execution, and control, and (vi) network nurturing. The paper is structured accordingly.

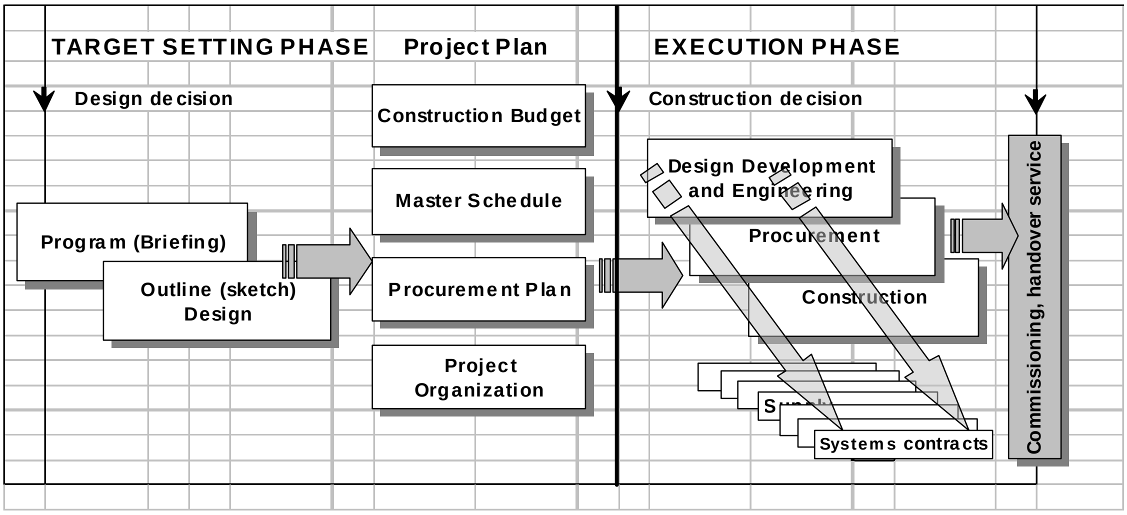

Figure 1: 2-phase building project process in the CM model in Finland.

2. Virtualization of A Traditional Building Contractor

2.1 Flat and Virtual Organization

Herein, a traditional building contractor competing in the context of the building market in Finland is transformed toward **a flat and virtual organization** through outsourcing. There are several flat features, i.e. all middle levels of management are removed and functional units such as cost estimation, procurement, and building design services are outsourced (Figure 2) [1]. Prior internal project staff is encouraged to act as entrepreneurs who form a staff pool from which a virtualized contractor assigns key staff to each project separately. Client accounts are introduced in order to enhance the true engagement of account managers in quality assurance and client care. The remaining flat and virtual organization consists of company management and experienced project managers only. For each project, one project manager is assigned to carry the PM responsibilities through all phases. For the design phase, a project manager heads a building design team together with client representatives, an architect, various engineers, and a consultant. During the bid or proposal preparation, a project manager heads the buying of estimation services and the allocation of procurement packages via competitive networking. When a particular bid is won, a project manager mobilizes a site organization from a staff pool and (s)he also manages the construction phase.

Company management is responsible for arranging and developing the competitive and collaborative networking with selected members as well as enhancing supplier relationships and assuring each member’s additional competencies in the case of possible extensions of contract scope. Each project manager retains a responsibility to hand out the procurement contracts for her/his ongoing project. The **five core-business processes** of a flat and virtual contractor include (1) client relationship management, (2) sales and bidding (competitive or negotiated), (3) product design management, (4) procurement and construction management, and (5) handing-over and after sales services.

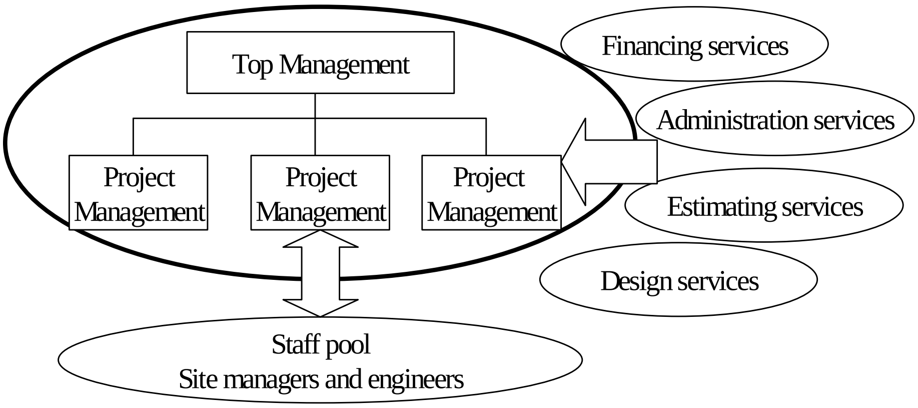

Figure 2: Flat and flexible organization model for a VCMSC [1].

2.2 Competitive Networking

In the context of building in Finland, all such forms of partnering that are based only on long-term one-on-one relationships have so far resulted in a loss of real competitiveness sooner or later. Thus, the delivery system of a VCMSC is based on **competitive networking** [1]. Procurement and PM processes are needed to ensure the product flexibility, design changes flexibility, short delivery times, and the concurrency of design, procurement, and the construction works on site. Networked members and external suppliers are motivated to add value-for-client money through their product expertise, whereas a VCMSC (i.e. a leading member) focuses on enhancing its CM and PM expertise. A procurement strategy is revised to allow the extension of delivery and contract scopes, a decrease in number of individual deliveries, and the creation of network membership with the most important suppliers. Competitive networking implies that a leading member networks with several special product contractors [12] that supply the same products, functional elements, or services (Figure 3) [1]. The profitable performance of a VCMSC's network would become endangered without internal competition.

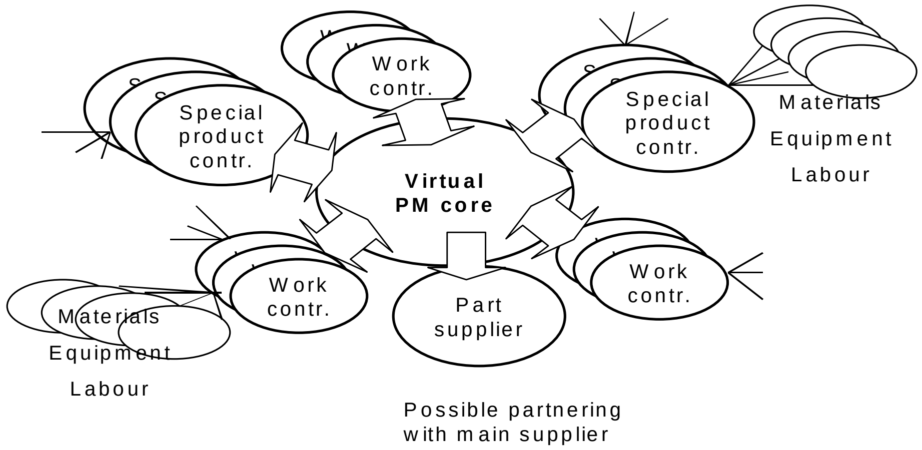

Figure 3: Delivery system of a VCMSC based on a leading member and competitive networking [1].

3. Management System Model of A VCMSC

3.1 VCMSC Management System

In the general CM context, individual practitioners are needed to perform various CM services for owners. The support for the assumption of this multitude is that a range of expertise required for performing all CM services and the demand for timely CM performance on projects precludes the performance of complete CM services by an individual firm, except on the simplest of projects [3].

Herein, a VCMSC is defined as a dynamic network of collaborating entities that reconfigure around a virtual core whenever an opportunity arises [2]. **The proposed management system** of a VCMSC consists of six subsystems, i.e. (1) Project owner relations management system (PORMS), (2) Project offerings and bidding management system (POBMS), (3) Project design and engineering management system (PDEMS), (4) Project procurement management system (PPMS), (5) Project construction, execution, and control management system (PCECMS), and (6) Project network nurturing management system (PNNMS). Next, each of these subsystems are defined briefly to facilitate an understanding of the scope of the VCMSC's management system and explain how each sub-system fit into the overall functioning and the execution of complete services by a VCMSC.

3.1.1 Project Owner Relation Management System (PORMS)

In general, when **construction companies** face increasing competition, cooperation between owners (clients) and contractors is emphasized. The role of a project manager is vital for mutual trusting relationships and customer satisfaction [13]. Client satisfaction can be defined as how well a contractor meets the expectations of its clients, which is in return one of the measures of a contractor's performance. The expectations of a client are affected by the building needs (investment) in question, past or direct experiences with the same contractor and the similar ones, word-of-mouth information, and the contractor's marketing activities and image. A decision of a client to appoint the same contractor for the next project is strongly influenced by past experience, as decision makers either have strong normative beliefs or they rely on the advice of their representatives. Typically, the former guide the procurement behaviour of a client in the case of the regular procurement of buildings and a high level of repeat business [14].

However, traditional marketing seems to be ineffective in such competitive arenas where potential clients are identifiable and the focal CM firm target each of them. Herein, a VCMSC enhances the quality of its services through **the pre-emptive expert relationship building** with targeted existing and potential new clients (owners). In particular, the abundance of various contacts through a pool of the networked members will enable a VCMSC to generate repeat business, positive rumours, and so on. Through **its PORM system**, a VCMSC generates and updates a list of the most potential clients (Figure 4).

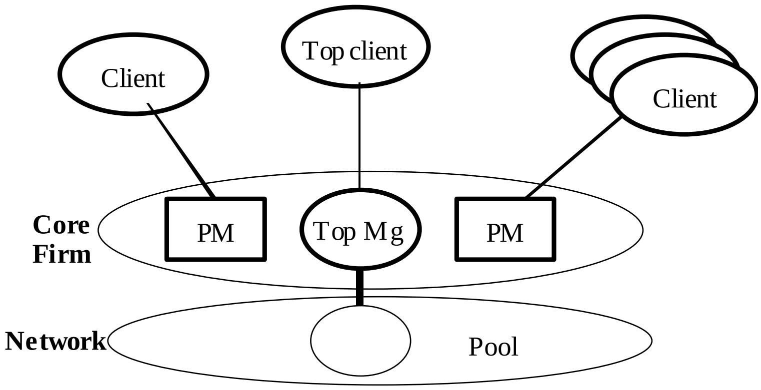

Figure 4: Project owner relation management system (PORMS).

Company management and project managers act as client accounts for ensuring future work. Continuous investments in client relationship management are fairly high (aligning with [14]). However, we expect that future returns will turn out be much higher when a VCMSC will capture a series of CM contracts behind a protective "wall" consisting of the normative beliefs of the collaborative clients.

3.1.2 Project Offerings and Bidding Management System (POBMS)

In building bidding processes, a productive breakdown makes it possible to define work scopes accurately enough to eliminate overlaps and gaps between the work scopes [15]. One of many innovations of the CM system is multi-bidding and multi-contracting which minimizes frequent and difficult construction trade interfaces, provides each contractor with as much construction continuity as possible and schedule effectiveness. This is so because more control is given to each contractor over its own program and finger pointing is reduced in the event of interfacing contractors with different priorities. Multiple contracting provides a simple way to involve target contracting groups. Regardless of why they are targeted, it is possible to reserve specific work scopes for exclusive bidding by contractors in the group. Deciding which work scopes to set aside depends on the match-up of contractors in the target group and the requirements of the work scope [3].

However, traditional subcontracting prevents both an owner and a principal contractor from inviting subcontractors to innovate and deliver their best (new) solutions based on the accumulated professionalism. Thus, **the leading member of a VCMSC** collaborates herein with a competitive network of eligible members, i.e. special system contractors (SSC) with their own special resources; material, equipment, labor. With **its POBM system**, the leading member performs the work scope breakdown and prepares a list of bid packages, buys bills of quantities and a cost estimate from an expert consultant(s), and distributes the bid packages (aided by advanced IS) to a set of networked SSCs for the bid preparation. The goal of a bidding process is to generate the most attractive solution to a client. A project scope needs to be large and versatile enough so that the project becomes a viable target for a VCMSC with its specialty network. As a rule, each package will be bid by at least three members (incl. external SSCs) who have room in work load, available staff, resources, and an interest to submit a proposal (Figure 5).

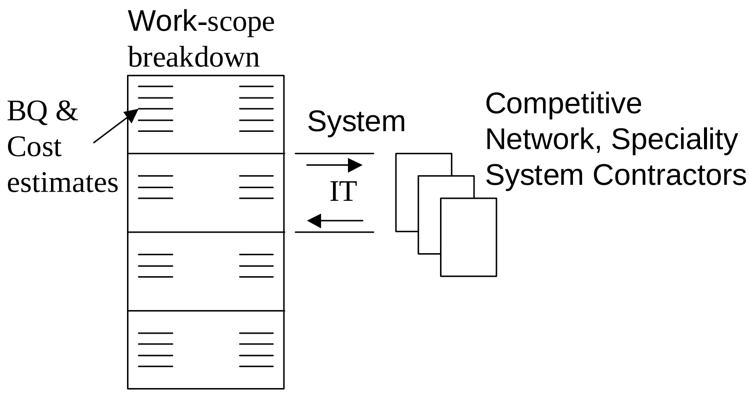

Figure 5: Project offering and bidding management system (POBMS).

The top management of the leading member makes all the decisions during the networked bidding process. A POBM system enables to understand client needs fast, compile the best offering, divide work scope among SSCs and obtain the most competitive prices for each package.

3.1.3 Project Design and Engineering Management System (PDEMS)

In general, design and construction practices and project delivery systems have moved toward **the integration** which has encouraged stakeholders to manage design and construction processes concurrently in causally overlapping phases. Narrowing gaps between design and construction through the integration improves constructability especially during pre-construction phases (conceptual planning, design development, procurement). A design development phase consists of (a) schematic design where a design team investigates alternative design solutions, and (b) detailed design where a design team evaluates, selects, and specifies the systems and components of the building project in question. A lack of construction knowledge/experience integration in planning and design processes can lead to constructability problems during construction phase because most design professionals have only little experience in construction practices, local considerations, availability of different resources, and so on. During the procurement phase, when a project formally transitions from the design preparation into the construction preparation and when the project bidding and awarding is performed, a contractor's reliance on the contract documents to visualize the construction process limits its ability to become more familiar with the project in question [16].

However, the traditional stage model where all the design documents are completed before the related procurement (and construction work) is too slow and does not allow to utilize the networked expertise in real-time. Thus, **the PDEMS** is herein designed to improve constructability as this subsystem provides network members, special system contractors, with a platform to contribute early enough to the detailed design of the project packages that are

allocated to each of special system contractors. The leading member of a VCMSC establishes **a product model** as the core of a PDEMS which enables the effective exchange and change of project information. In each project, all project stakeholders are having the real-time access to the most recent design documents. Typically, a pre-construction constructability review is divided into the sub-reviews that take place by design packages. Designers get on time the real-time feedback regarding design changes and adaptations through the design layout reviews and the identification of design conflicts (Figure 6).

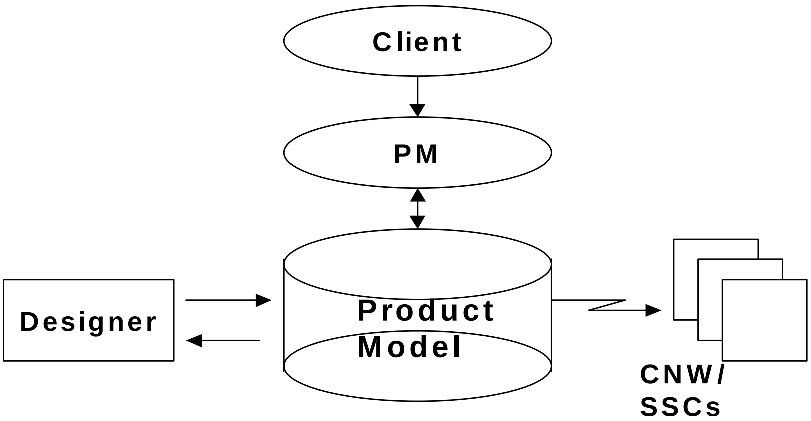

Figure 6: Project design and engineering management system (PDEMS). (Key: CNW refers to the network and SSCs to special system contractors.)

3.1.4 Networked Project Procurement Management System (NPPMS)

In general, partnering in its simplest form is a commitment between two or more organizations to work together for the common purpose of achieving specific business objectives by maximizing the effectiveness and benefits of cooperation. **Partnering agreements** can be created in various forms to suit particular objectives, "strategic alliances" organizations are one of the more common forms of partnering in which two or more strongly positioned or dominant suppliers partner with equally dominant customer(s) because they have a mutual dependence on each other [16]. Partnering provides an opportunity for cooperative contracting in which the open, competitive bid process keeps the parties at arms length prior to the award of the contract, and once the contract is established there are major benefits to all partners from the development of an organizational culture characterized by trust and cooperation. Building partnering infrastructure requires leaders who determine the degree to which the organization is structured to support its strategic objectives, redesign the organization as a partnering network to ensure that the organization's culture is aligned both with its partnering philosophy and processes.

Herein, **the NPPMS of a VCMSC** provides the members of the network with the internal arena to compete effectively in order to come up with the integrated best offering. On the other hand the **leading member of the VCMSC** will be able to move towards outsourcing those processes which are not part of its own core skills. When a project opportunity arises, the leading partner notifies the members, i.e. special system contractors via Internet data transfer to post their offers/bids, selects the bids, and notifies the winning bidders, who will in return take part in the detailed design, or do it altogether, and provide tailored solutions as part of their bid packages. Systems are herein divided into the five principal categories [18]: (i) base building systems (ground work and excavations, demolition, foundations and building frame, roof, facades and outer levels), (ii) permanent space systems (stairs, entrance halls, auditoriums etc.) and components, (iii) technical building services systems (HEVAC systems, information systems etc.) or technical base systems (technical core), (iv) flexible space systems (separate space areas or departments, HEVAC techniques of the space infills), and (v) exterior area systems (area structures, including HEVAC technical work). The system allows the special system contractors to collaborate in order to win new business and develop new projects, even concentrate the weight of a large company yet retain the speed and flexibility of a virtual network.

3.1.5 Construction, Execution, and Control Management System (CECMS)

The advanced management of construction projects is a problem in information, or rather, a problem in the lack of information required for decision-making. In order to keep the projects rolling, decisions have to be made before all the information required for the decision is available. Decision-making is about robust decisions, rather than optimal decisions [19]. Key decisions concern project quality, schedule, budget, and information itself. In the same vein, **the CECMS** of a VCMSC provides the leading member or the CPM team with an advanced planning system in which the workplaces and the coarse general planning are combined, the detailed activity planning are done just before beginning of each activity, and short time rolling window is used trough the whole project. The corrections must be performed immediately. If work stops in one workplace, it is jumped over and a new team will be allocated (Figure 7).

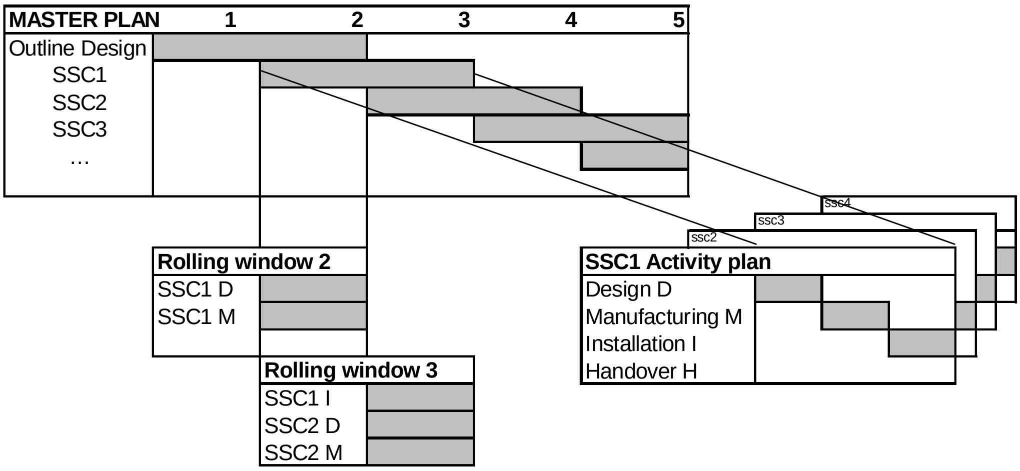

Figure 7. Construction, scheduling, execution, and control management system (CECMS).

The CPM team plans **a master plan**, which contains the main systems or packages to be performed and the special system contractors performing them without too many details. For control purposes, the critical path and milestones are made together with their dependencies. Each of the special system contractors plans its activity plans/schedules which are re-integrated into the real-time master schedule(s). An activity plan is prepared in the way that allows each activity to be presented in a rolling window in detail just before it starts to show what sub-system and work will be executed on site and how.

3.1.6 Network Nurturing Management System (NNMS)

In principle, A leading member acts as a strategic center and expects its network members to follow rules and meet contractual obligations. **Involvement with network members** beyond traditional subcontracting includes several key issues such as developing the competencies of the members, borrowing, developing, and lending new ideas, and sharing perceptions of the competitive process and customer needs. The quality of relationships and the shared values differentiate and define the boundaries of a network organization [17]. Among **longer-term, close relationships,** there are various approaches such as a close single source, preferred supplier relationships and arms-length competitive tendering relationships. Suppliers are assessed in terms of three categories: (a) strategic suppliers, who are awarded long-term arrangements but normally only as preferred rather than single source suppliers, (b) non-strategic suppliers, who are procured through more arms-length relationships, and (c) specialist suppliers, who are also awarded long-term supply agreements, often on a single source basis. The initial selection for long-term supplier status is done on a basis of the volume and/or the strategic importance of a project [16].

Herein, the **NNMS** enables the **leading member of a VCMSC** to develop the competences of its network in order to produce innovative building solutions that will ultimately lead to a success in new projects. The leading member needs to work more closely with the networked members to ensure that system specialist contractors of the right caliber are selected, who would develop the required expertise both in the short and longer term. Shorter lead times and construction periods as well as higher cost certainty and a larger scope for cost reduction can be achieved through a deeper degree of integration between system specialist contractors. A leading member may choose the core VCMSC team project by project. One of member selection strategies implies that each building scheme is approached on a "fit-for-purpose" basis, i.e. the required expertise and competences are determined and the necessary functional areas are specified for the project in hand. Overall, high effectiveness is gained through providing key members with continuous workload and improving synergic project performance along the joint principles of competence nurturing. On the one hand, a special concern is given to the avoidance of monopolistic dependency when nurturing network relationships. A viable VCMSC cannot become dependent on any single special system contractor. On the other hand, none of these special system contractors should become fully dependent on one particular VCMSC. In other words, the former are encouraged to compete both individually and through other colaborative arrangements in other competitive arenas to gain more experience and knowledge of better practices.

4. Conclusions

In short, a VCMSC is defined as a dynamic competitive network of collaborating special system contractors that reconfigure around a leading member whenever an opportunity arises. It is proposed herein that **the viable management of a VCMSC** involves the six areas or dimensions along which each of the corresponding subsystems are designed and leveraged. Initially, some key principles of VCMSC management are distilled as follows. First, advanced owners of buildings are the ones that gain the highest value-for-money through the reliance of virtual construction management contracting. Second, a competitive network is established and motivated in order to achieve sustainable-like advantages over a series of projects. Third, the special system contractors produce all the systems and solutions that make a viable whole or a building. They also deliver all the changes that are leveraged in real-time to all network members. Fourth, the real competitiveness is measured through the integrated offerings and procurement of a set of the systems project by project. Fifth, the advanced construction project management is based on a master plan and a set of activity plans/schedules with rolling windows. Sixth, the conditions of sustainability of a VCMSC include the continuous renewal of the network, the nurturing of the innovation competences, and the advanced ways of integrating the network through the other five areas or dimensions. In the near future, **the empirical inquiry and the testing of the subsystems** will take place to validate the suggested VCMSC model, overall, in the context of the building market in Finland. In turn, the advanced information systems and solutions need to be specified, procured, and applied to support the VCMSC management system. For this endeavor, all interested foreign experts in virtual CM and networking are welcome to join the TKK/CEM development team.

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Analysis of the Organisational Culture Profiles of Construction Firms in China

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Abstract

The vast economic growth in China in the past decade has brought about a unique opportunity for the development of China's construction industry. However, China also faces many challenges and uncertainties resulting from the fast changing economic environment. The construction industry has been criticized for poor performance and low effectiveness in terms of quality and profitability. Given that organizational culture plays a significant role in work performance and effectiveness, this paper presents a culture – effectiveness model for investigating the Chinese state-owned construction enterprises. The culture – effectiveness (C-E) relationship has received increased attention in organizational research although there remain significant questions over the existence and strength of such a relationship. This paper presents the results of cluster analysis of the culture profiles of Chinese construction enterprises and develops a model for investigating the C-E relationship.

Keywords: Organizational culture, effectiveness, Chinese contractors, state-owned enterprises.

1. Introduction

The past decade has witnessed China's rapid and extensive economic growth that has brought about a major opportunity for the development of China's construction industry. The value of the total investment in fixed assets in 1999 amounted to 2988 billion RMB Yuan while it was only 91 billion in 1980 [1, 2].

However, Chinese construction companies (state-owned enterprises) are often accused of poor performance and low effectiveness in terms of quality and profitability [3, 4]. Hence, ways to improve the effectiveness of the Chinese construction companies are considered important and the postulation that there is a relationship between organisational culture and organisational effectiveness becomes a focus for investigation.

There are many environmental and project factors that affect the performance effectiveness of the state-owned enterprises in construction (SoEs) and that, one could argue, may fall outside the immediate control of the SoEs. However, organizational characteristics that fall under the control of management, and which represent how the enterprises organize themselves in response to the environmental challenges, are most crucial in determining consistency of their effectiveness appropriately. It is argued that the ability of the SoEs to both well organize themselves internally and respond to the environment externally comes from the organisations' cultures, an intangible force currently believed to play a tangible role in affecting the competitiveness, development and ultimate survival of the SoEs [5].

2. Organizational culture and effectiveness: a review

In the past twenty years, it has been increasingly recognized that organizations, ostensibly similar as they are in terms of structure, may differ substantially in their performance and effectiveness. There seems to exist factors which permeate organizational life and influence every aspect of organization operation. The study of organizational culture stems from such realization, by organizational scholars as well as practitioners, with a belief that once the ambiguity and unpredictability of organizations are better understood, their performance and effectiveness could be greatly improved by adopting better organizational designs [6]. As Schein [7] puts it, "The concept of organizational culture holds promise for illuminating this difficult area" and since the early 1980s, culture studies have acquired prominent status in the management field.

The purposes of studying culture are many; but the principal purpose is to find out how it affects organizational performance with a view to improving effectiveness – arguably one of the most important organizational-level variables. Such culture-effectiveness link studies (see [8], [9] can be divided into the following three stages:-

2.1 The Budding Stage

In the field of organizational research, the culture-effectiveness link studies developed alongside the emergence of the human relations school in the middle of the last century, with the Hawthorne studies being the pioneer, indicating implicitly how group culture affects performance. Jaques [10, 11] related the customary and traditional ways of thinking and doing things to the working behaviours of employees. Although the effects of the commonly shared "ways of thinking and doing things" are not directly investigated, his findings indicate that organisational culture could be a serious barrier to productivity if it were not congruent with the organizational structure and environment. Pfiffner and Sherwood [12] suggest that there may be a relationship between the culture and the effectiveness of a firm, but they do not conduct any further investigation of the nature of such a hypothesized link. Silverzweig and Allen [13] are the first to intentionally and explicitly look into the effect of culture on the performance of a company. Of their eight case studies, which involve various branch organizations that have suffered losses and intended to raise their effectiveness, six organizations improve their performances substantially after changing their culture. Such findings lead them to suggest that there is a close link between culture and performance of an organisation.

2.2 The Promulgation Stage

The end of the 1970s marked a clear change from implicit attention to the culture-performance/ effectiveness link, with the attempt to explain the shining success of Japanese enterprises at that time. Ouchi is one of the outstanding scholars to arouse people's attention to the importance of employees' commitment and the unitary vision for the company's success, by arguing [14, 15] that emphasis on certain humanistic values contributes to the company's economic performance. These values include employee-concern and consensual decision-making which, generally, characterize Japanese enterprises. Based on their experiences with more than 30 Japanese and American companies, Pascale and Athos [16] put forward a similar idea that the higher productivity of Japanese firms is attributable to their emphasis on human relations, by arguing that focus on skills, style and employee goals lead to high performance. That strong culture has made the difference between successful firms and less successful ones is claimed by Peters and Waterman [17], who argue that superior performance is to be achieved only if the firms move to a more adaptive and humanistic approach from pure technical and rationalistic approach. Deal and Kennedy [18] also put out a similar view that a strong culture is not only able to respond well to the environment, but also to changing circumstances, thus enhancing the performance of firms. This period of the 70s to early 80s was characterized with a relatively popular belief that a link existed between culture and performance, but without much substantial evidence.

2.3 The Testing Stage

The doubts, scepticism and, even, contradictory findings [19, 20] concerning the culture-performance link led to a large volume of empirical studies from the end of 1980s to present, attempting to test such theoretically disputable link, as a further step in exploring and uncovering the cultural phenomenon of organizations. The major researchers include: Barley, Meyer and Gash [21], Cooke and Rousseau [22], Dennison [23], Rousseau [24], Calori and Sarnin [25], Gordon and DiTamaso [26], Kotter and Heskett [27], Marcoulides and Heck [28], Petty, Beadles, Lowery, Chapman and Connell [29], Dennison and Mishra [30], Wilderom and Van den Berg [31], and Sawner [32]. The findings of research studies, though different to some degree, show a culture-effectiveness link. Relying on co-relational techniques, most of the studies are not able to establish a firm direction of such relationship, the significant correlations indicate possible causal relationship between organizational culture and effectiveness that should be investigated further [9].

While culture has been gaining in popularity in the general management field, culture studies in the construction industry also have intensified. Maloney and Federle [33, 34] introduce the Competing Values Framework as their paradigm for analyzing the cultural elements in American engineering and construction organizations. Gale [35] looks at culture as a means to reduce conflicts in construction. Seymour and Rooke [36] present their views of the culture of the UK construction industry. Rowlinson and Root [37] offer their views of the impact of culture on project performance. Hall and Jaggar [38] note the importance of culture differences in international construction. Liu and Fellows [39, 40] highlight the culture issues in project procurement and also explore the impact of culture on project goals. With Hong Kong real estate profession as the research context, Liu [41] explores the relationships between cultural dimensions, strength and the real estate professionals' perceived job satisfaction.

At present, culture research findings are not entirely consistent with one another, and sometimes even contradictory. Due to the complex nature of the constructs of "organizational culture" and "effectiveness", there is a lack of an integrative and comprehensive framework for C-E (culture - effectiveness) research.

3. Developing the C-E linkage model

3.1 Behavioural Approach

Much of the research on organizational culture has emphasized the central importance of the values and beliefs that lie at the core of an organization's social system. However, one of the key challenges in research of the organizational culture and effectiveness (C-E) link relates to the establishment of a theoretical basis for explaining the assumed relationships [9]. In such C-E link studies, most of the ideas about the relationship between culture and effectiveness have attributed the success of organizations to some combinations of values, beliefs and practices. Such attributions imply a general framework that organizational effectiveness is a function of organizational culture.

Although this framework shows the link between these two organizational variables of culture and effectiveness, it offers nothing more than a superficial one – without indicating the mechanism of how organizational culture operates on the final organizational outcome, leaving such an "organic process" ignored as a "black box". In order to substantiate the assumed link, the organizational culture operating mechanism on behaviour has to be investigated in more detail.

In the study of organizational behaviour, one of the traditional theories is the S-O-R (Stimulus-Organism-response) sequence [42] which has been applied by Liu and Walker [43] in the modelling of the construction procurement process in terms of the B-P-O (behaviour-performance-outcome) cycle. Given the idea that organizational culture is the "software of the mind" [44] that is shared by organizational members, it influences the cognition and perception of its members, guides their behaviours, integrates its internal processes to ensure the ability to survive and adapt to the environment [45, 7, 22, 23, 30, 46]. Therefore, it is postulated that organizational culture can be taken as the "stimulus" for the adoption of various behaviours in the organization.

3.2 Schema Theory

Based on a detailed review of the social cognition literature, Markus and Zajonc [47] conclude that schema theory is the most useful and pervasive perspective on the mechanics of social cognition. Many definitions appear in the current literature. However, the definition offered by Marshall [48] might be the most comprehensive: "A schema is a vehicle of memory, allowing organization of an individual's similar experiences in such a way that the individual can easily recognize additional experiences that are also similar, discriminating between these and ones that are dissimilar; can assess a generic framework that contains the essential elements of all these similar experiences, including verbal and nonverbal components; can draw inferences, make estimates, create goals, and develop plans using the framework; and can utilize skills, procedures, or rules as needed when faced with a problem for which this particular framework is relevant". As implied from the above definition, schemas serve as mental maps which enable individuals to orient themselves within their experimental terrain and guide interpretation of the past and present, as well as expectation for the future [49]. The seven functions listed below is the most comprehensive summary from Taylor and Crocker [50]:

§ Providing a structure against which experience is mapped;

§ Directing information encoding and retrieval from memory;

§ Affecting information processing efficiency and speed;

§ Guiding filling gaps in the information available;

§ Providing templates for problem solving;

§ Facilitating the evaluation of experience;

§ Facilitate anticipating of the future, goal setting, planning, and goal execution.

Schemas are dynamic. As schemas incorporate more and more new information, they become expanded and more and more elaborate [51, 52, 53, 49]. Schema theory suggests very important implications for expanding our understanding of the role of organizational culture in guiding sense-making in organizations. According to Rumelhart [54], knowledge about any stimulus can be schematized and, therefore, individuals can have at their disposal many schemas. Harris [49] argues that organization-context-specific schemas are most relevant to understanding organizational culture, since social knowledge is generally contextually bound. Culture scholars usually stress human motivation from the perspective of culture. However, to assume that individuals are endowed with a fixed set of needs and that a social institution is there to satisfy them commits a fallacy of abstract individualism and yet to assume that culture is unproblematically internalized is to "over socialize" the individual and oversimplify the process by which a person actively appropriates socially shared meaning [55]. Strauss [56] argues, in a broader sense, that human motivation is "the product of interaction between events and things in the social world and interpretations of those events and things in peoples' psyches".

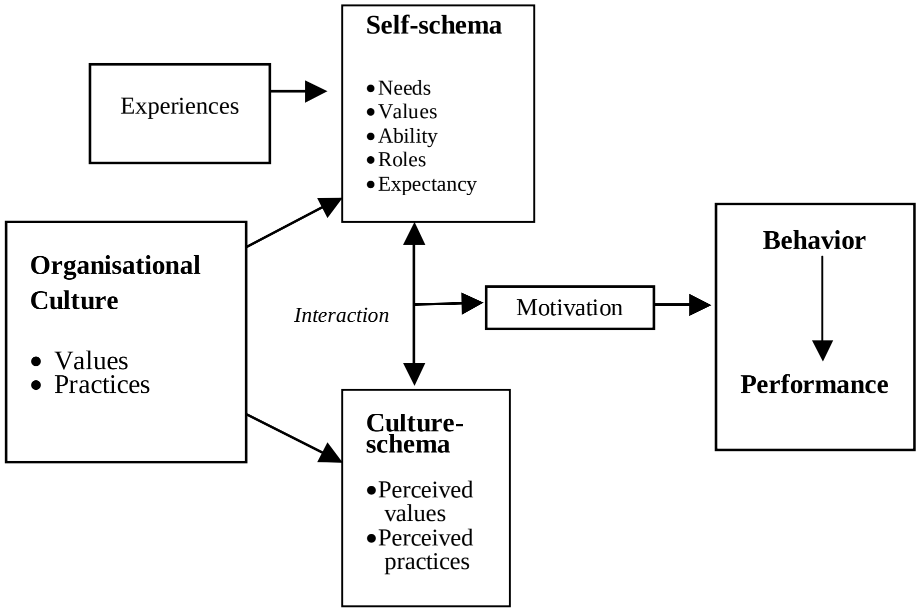

Figure 1: Organizational Culture, Schemas and Performance

Motivation theories suggest that people do what they do to satisfy their needs. Given all human conscious behaviours are motivated by their needs and goals [57], individuals tend to evaluate their performance against the attainment levels of such goals and the satisfaction levels of their needs as their behavioural outcomes. Such evaluation by organizational members is a process of comparing the organizational rewards of their behaviours and performance against what may be expected (goals) by them. In an organization, rewards are basically classified in two categories: extrinsic rewards and intrinsic rewards [58]. However, the satisfaction of the employees does not solely depend on having their own goals met and their own needs satisfied. Individuals are also concerned about the fairness of the rewards according to equity theory [59, 60]. Hence, the level of satisfaction is also influenced by the outcome of the individuals' "horizontal" comparisons with other organizational members, particularly their peers.

The above analysis focuses on the individual or micro level of outcome effectiveness. However, the performance of organizational members also leads to the organizational or macro level of outcome effectiveness, as the performance of the organization is, to a large extent, attributable to the aggregation of individual performances moderated by the external environment. The organizational-level effectiveness in culture studies is multi-dimensional, usually centering on such dimensions as customer service quality, market share and economic return, external adaptation and ultimate survival. Fig. 2 indicates the relationship between performance and effectiveness outcome.

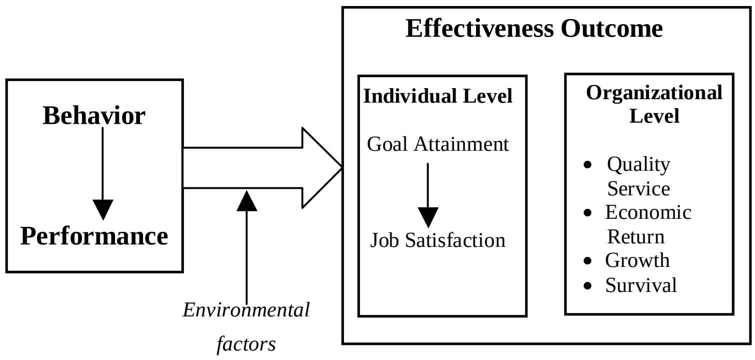

Figure 2: Performance and Effectiveness Outcome

3.3 Research Objective

From the above discussion of the relationship between organizational culture and effectiveness, this paper focuses on the following research objective relating to the Chinese state-owned construction enterprises:

To examine if the relationship between organizational culture and effectiveness is reciprocal and whether organizational culture is both an asset and a liability, depending on its positive or negative impact, on organizational effectiveness.

4. Research Design

The research design comprises three stages:

(1) The first stage comprises preliminary case studies of selected Chinese construction enterprises with the purpose to test and choose from two culture measuring instruments, i.e., OCI – Organisational Culture Inventory [61, 62] and OCAI – Organisational Culture Assessment Instrument [46]. Both OCI and OCAI have previously been widely used and tested as reliable in measuring organizational culture. Five construction companies from China north (Beijing and Tianjin) to China south (Shantou in Guangdong) are selected from the A Complete List of the Chinese Construction Enterprises (Ministry of Construction, 1989). The results of the selected case studies are presented in this paper (which, from respondents' feedback and Cronbach Alpha coefficients, show that OCAI is more suitable, in terms of validity and reliability, for measuring organizational culture of Chinese construction companies).

(2) (a) The second stage comprises a major survey of state-owned construction enterprises using OCAI to assess their organisational culture profiles and cluster analysis is applied to analyse that sample into groups.

(2) (b) An organizational effectiveness survey instrument is developed for measuring performance effectiveness of the same enterprises in stage 2(a). At the time of the stage 2 major survey, the organizational effectiveness instrument is administered together with the OCAI. The culture profiles from stage (2a) are mapped onto the effectiveness measures in order to analyse whether culture is a variable to explain the variance in organisational effectiveness.

(3) The third stage adopts a qualitative research approach by means of case studies selected from stage 2 to identify specific culture variables predominant in particular environmental contingencies contributory to performance effectiveness, thereby, to indicate future directions for research in organisational culture change.

5. Empirical Results

This paper reports the findings in stage 1, i.e. the preliminary case studies of five selected construction enterprises in order to identify the suitable culture measuring instrument.

Both OCAI and OCI are designed to measure the relatively shallow layers of organizational cultures, such as practices, norms or rules, and cultural phenomena, and these differences are likely to exist in the Chinese construction enterprises. OCI is empirically found to be lengthy (120 questions) and respondents remark that the questions are not very clear – as far as interpretation by respondents in the specific Chinese cultural environment is concerned. The response rate on OCI is disappointingly low at 8% compared to that of around 40% (see fig. 3) on OCAI. The Cronbach Alpha coefficients for the culture types in OCI are lower (8 out of 12 culture types with cronbach alpha less than 0.79, lowest being 0.22) than the OCAI (lowest cronbach alpha at 0.79), hence, OCAI is adopted for the stage 2 major survey.

5.1 Measuring instrument – OCAI

The OCAI, including its theoretical base in the Competing Values Model and the interpretation of the four culture types, i.e. clan, adhocracy, hierarchy and market, is explained in detail in Cameron and Quinn [46] and Quinn and Rohrbaugh [63]. Each culture type contains 6 questions, hence, there is a total of 24 questions in OCAI that describe six scenarios, including dominant characteristics, organizational leadership, management of employees, organizational glue, strategic emphasis, and criteria of success. Based on the "content" of these six scenarios, four types of cultures are formulated, namely, clan, adhocracy, market, and hierarchy. The six scenarios/questions are used to stimulate the respondents to interpret the relative resemblance of the cultures of their own enterprises. Clan culture describes an organisation that focuses on internal maintenance with flexibility, concern for people, and sensitivity to customers' adhocracy culture describes an organisation that focuses on external positioning with a high degree of flexibility and individuality; hierarchy culture describes an organisation that focuses on internal maintenance with a need for stability and control; and market culture describes an organisation that focuses on external positioning with a need for stability and control [46].

5.2 Data Collection

The construction enterprises in stage 1 and 2 are chosen on three basic considerations: (a) categorized as first-class construction enterprises[1] by the Ministry of Construction (MoC), (b) engaged in building construction, and similar in organization size; (c) respondents hold relatively high positions. Five construction enterprises are selected for stage 1. The major survey in stage 2 consists of stratified sampling from a total of 552 first class SoEs. The number of respondents from each enterprise in stage 1 is given in fig. 3.

[1] According to "*Administrative Regulations of Construction Enterprises* " [64], construction enterprises are categorized into 4 classes: First Class, Second Class, Third Class, and Fourth Class. In the first-class enterprises, there are 29 sub-groups such as building (civil and industrial engineering), chemical and hydro engineering; highway and transportation engineering, of which building construction enterprises are the largest subgroup.

5.3 Data analysis

The culture mean scores of the five enterprises in stage 1 are given in fig. 3. ANOVA confirms that all five enterprises differ significantly on all the OCAI questions relating to the four culture types. The figures marked in **bold** in fig. 3 denote the dominant culture type in the particular enterprise.

Fig. 3 Mean Culture Scores of construction enterprises in stage 1

Enterprise / Culture type	1 Beijing	2 Langfang	3 Tianjin	4 Gezhouba	5 Shantou	Average	N	Cronbach Alpha
Clan	2.8326	2.9717	3.0240	3.2614	2.3952	2.9391	182	0.79
Adhocracy	2.0088	1.8468	1.7070	1.7100	2.8590	1.9462	185	0.86
Market	3.2280	3.0319	2.1667	2.2105	3.4102	2.7084	171	0.88
Hierarchy	3.5746	3.4667	3.5323	3.0738	2.3513	3.3441	178	0.84
Respondents (N)	38	35	56	38	26			

On average, hierarchy culture is the predominant type (mean score of 3.3441), however, the Shantou enterprise is the exception with a predominantly market-oriented culture.

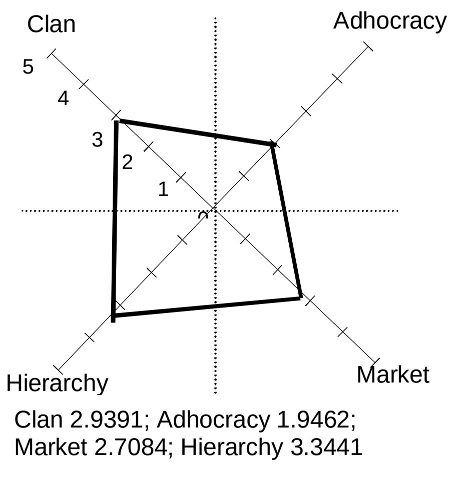

Figure 4: Mean organisational culture profile of construction enterprises

To attempt to represent organisational culture in four distinct types/profiles would be misleading. The four types adopted by Cameron and Quinn [46] provide a basis to systematically organize culture variances at the organizational level but does not pretend to be comprehensive of all cultural phenomena – especially at national level. The framework of the four culture profiles supports a platform to interpret key elements of organizational culture that can foster change and improvement in organisations, i.e. a framework that provides an "intuitively appealing and easily interpretable way to foster the process of culture change" [46].

Findings from stage 1 of the five selected cases show that:

- cultural difference exists at the corporate level of the Chinese construction enterprises,
- of all the four culture types, hierarchy and clan are stronger than market and adhocracy.

This implies that, although there exist cultural differences at the corporate level, the Chinese traditional national culture, characterized by Confucianism and nurtured by decades of highly unified political ideology and centralized planned economy, has great influence at the corporate level. However, China's recent open and reform policy has been exerting impact on its current culture, which can be reflected from some of the individual cultural traits in the enterprise 5. (Enterprise 5 is located in Shantou, in the south of China, which is more exposed to western market influence). The cultural results reflect the general status of China's mixed and transitional characteristics, politically, socially and economically.

In the next stage of research, cluster analysis is to be carried out to classify the enterprises into groups that share similar organsiation culture profiles across the four culture types, scores at the individual-level for each type of culture need to be aggregated into the organsiational (enterprise)-level. In order to test if a particular culture profile, is more effective than the others, the clusters of SoEs (with different culture profiles) will be tested for comparison of their organizational effectiveness indicators by Kruskal-Wallis test.

6. Conclusion

This paper presents a theoretical framework developed for investigating the culture and effectiveness of Chinese construction enterprises. It also offers a proposed methodology for testing the C-E hypothesis by collecting empirical data from the Chinese construction industry. The pilot study in stage 1 shows that the OCAI questionnaire can be used in assessing the culture profiles of the Chinese companies and that differences seem to exist in different regions (especially that which have been exposed much to western market influence) although hierarchy and clan cultures still dominate.

Three important factors that shape the culture of an organization have acquired the consensus of culture scholars, summarized as [6]:

- The societal or national culture within which an organization is physically situated;
- The vision, management style and personality of an organization's founder or other dominant leader; and
- the type of business an organization conducts and the nature of its business environment.

Considering the traditional Chinese culture and the current status of the Chinese construction industry, the above general culture profiles of Chinese construction enterprises seem to be consistent with the particular Chinese context. Hierarchy culture is still at the dominating status that reflect 40 year's centrally-planned economic system with all the enterprises being of an institutional nature that strongly focused on "order", which eventually led to the widely-criticized "red tape". The second dominating culture, clan culture, reflects the traditional Chinese culture that focused on "harmony and *guanxi*" and "people-orientation". With the recent 20 years' economic reform, there appears to be more and more competition in the Chinese construction industry which, in turn, leads to the internal market culture of the Chinese enterprises. The very low score of adhocracy culture in the general culture profile suggests that innovation and risk-taking spirits are still quite absent among Chinese construction enterprises.

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Section IV

Human resource management

The importance of workplace support and work flexibility for civil engineers

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Abstract

This quantitative study examined the relationship between a supportive work culture and the work and life experiences of Australian civil engineers. Data were gathered from a sample of 1000 male and female civil engineers in a wide variety of work and family situations. The research investigated the level of work-family conflict perceived by civil engineers and the work-family balance values of their employing organisations. In addition the relationship between these work culture perceptions to other variables, such work and non-work satisfaction and burnout was investigated. The results indicate that civil engineers who perceive their organisation's values to support both their work and family life reported greater job satisfaction as well as lower intentions to quit. The results also demonstrate the "buffering" effect of flexible practices and a supportive work environment. It was found where organisations had flexibility and organisational values supportive of work and family integration, the positive relationship between work-family conflict and burnout was reduced. The implications of these findings for organisations employing civil engineers are discussed.

Keywords: organisational culture, civil engineers, work-family conflict, burnout.

1. Introduction

1.1 Background

Considerable changes, not only in the demographic composition of the workforce, but also in the roles and expectations of men and women have led to organisational and employee attempts to reconcile responsibilities in the work and non-work domains. Many job and organisational features found to impact negatively on family and non-work life are pertinent to civil engineers. These include long and irregular work hours, schedule inflexibility, high job demands, job insecurity and frequent relocation [1, 2].

This paper reports on findings of a recent research project investigating civil engineers and their perceptions of how supportive their workplaces are towards greater work and family balance.

1.2 Work Family Conflict and Organisations

Legal requirements and organisational performance issues appear to be at the core of the many arguments put forward for supporting employees' lives outside work. Legislation that stems from a social justice base, presents a strong motive for companies to address the concerns of their employees with family responsibilities. Along with most industrialised countries Australia has adopted equal opportunity legislation promoting equal work conditions for men and women. In 1990, Australia ratified International Labor Organisation (ILO) Convention 156, addressing workers and their family responsibilities. Consequently legislative and industrial reforms have flowed through, prohibiting dismissal on the basis of family responsibility as well as improving working conditions [3].

Organisations are also increasingly recognising the positive benefits of work-family initiatives. Decreased levels of work-life strain have been found to result in increased job satisfaction, decreased employee turnover and improved levels of organisational commitment [4]. Organisational variables such as schedule flexibility, supervisor support and time overload [5, 6, 2], and family-related variables such as parenting overload, spousal and familial support, and family distress [2, 7] have been found to directly influence family relationships, work-family conflict and intent to leave the workplace [8]. Support from supervisor, spouse and family, have been shown to reduce work-family conflict through their impact on role overload and work distress [7, 9]. Burnout is also associated with increased work family conflict, as well greater levels of absenteeism and turnover, and reduced organisational effectiveness and job satisfaction [10, 11, 12]. At an individual level, burnout has been associated with anxiety, depression, reduced self-esteem and substance abuse [13].

1.3 Supportive Work Culture

Grover & Crooker (1995) found that employees in companies with family-supportive benefits had higher levels of affective commitment to the organisation and expressed lower turnover intentions, regardless of whether the employee individually benefited from the policy [14]. Grover and Crooker postulated that work-family benefits had a positive influence on employees' attachment to the organisation because they signified corporate concerns for employee well-being. However while providing work-family policies and initiatives is important, it is imperative to recognise that these will have very little worth, and employees will not feel secure in utilising them, unless their value is entrenched within the culture of the organisation [15]. Many work practices assume that an employee's work domain is totally isolated from their family domain.

Denison defined organisational culture as "the deep structure of organisations, which is rooted in values, beliefs, and assumptions held by organisational members." [16, p624]. Bailyn [17] outlined three characteristics identifiable in a family-friendly work culture: flexible work scheduling, flexible work processes and an understanding by organisational leadership that family needs are important. Warren & Johnson [18, p163] consider a culture can be classified as family friendly when "its overarching philosophy or belief structure is sensitive to the family needs of its employees". Thompson, Beauvais & Lyness [19, p394] expanded the understanding of work-family culture to include the "shared assumptions, beliefs, and values regarding the extent to which an organisation supports the values and integration of employees' work and family lives." They consider a negative work-family culture to have at least three components; organisational time demands or expectations that employees prioritise work over family, negative career consequences associated with utilising work-family benefits, and lack of managerial support and sensitivity to employees' family responsibilities. Research has shown that supervisors play a key role in the effectiveness of both the implementation and utilisation of work-family policies and that employees' whose supervisor supported their efforts to balance work and family were less likely to experience work-family conflict [5]. Supervisor support is also an important buffering factor in the relationship between work family conflict and burnout [6].

Much research has proposed that workplace support can play an important part in assisting employees manage their work and family responsibilities. However little research has specifically focused on the supportiveness, or otherwise, of the organisations employing civil engineers. This research will determine the prevalence of supportive organisational values and the level of work-family conflict perceived by civil engineers as well as testing several hypotheses regarding influences of, and on, supportiveness, flexibility, work family conflict and emotional exhaustion. The hypotheses which will be considered are as follows:

H1: Respondents who consider their workplace to be supportive of a balance between work and non-work responsibilities will also report lower levels of work to family conflict, greater levels of job and life satisfaction and lower intentions to quit.

H2: Work load and organisational time demands will have a main effect on work family conflict (WFC).

H3: There will be a positive relationship between work family conflict (WFC) and emotional exhaustion (EE).

H4: Managerial support will moderate the relationship between work family conflict (WFC) and emotional exhaustion (EE).

H5: Work inflexibility will moderate the relationship between work family conflict (WFC) and emotional exhaustion (EE).

2. Method

2.1 Sample

The sample was recruited with the help of an Australian professional organisation for engineers. Data were collected using a self administered questionnaire sent to 500 male and 500 female civil engineers aged between 25 to 55 years. Questionnaires were completed anonymously and returned in a reply paid envelope. Of these, 208 participants returned completed questionnaires, with an additional 30 labeled "return to sender" resulting in a return rate of 21.4%. Three participants were excluded as they had either failed to complete the majority of the questionnaire, or wrote that they did not identify themselves as civil engineers. The final sample consisted of 205 civil engineers, 78% who were partnered and 52% who had children. The sample consisted of 112 females and 92 males that had an average age of 36.7 years, and an average working week of 45.4 hours (SD = 10.4). Further information on the sample can be found in Table 1.

Table 1: Demographic characteristics of the sample

	N	%		N	%
Gender			**Age**		
Male	92	44.9	up to 30 years	57	27.8
Female	112	54.6	31 - 40 years	81	39.5
			41 - 50 years	55	26.8
Work hours/week			over 51 years	10	4.9
20 hours or less	5	2.4			
21 - 35 hours	16	7.8	**Family Structure**		
36 - 45 hours	99	48.3	Couple with dependent children	90	43.9
46 - 55 hours	66	32.2	Couple with non-dep children	15	7.3
56 hours or more	19	9.3	Single parent	9	4.4
			Couple without children	53	25.9
No of employees in organisation			Single person	38	18.5
1 – 19	32	15.6	**No of Children**		
20 – 49	25	12.2	0	95	46.3
50 -199	24	11.7	1	23	11.2
200 – 999	55	26.8	2	55	26.8
1000 or more	66	32.7	3 or more	28	13.7

Respondent's employment within the public sector was 34.6%, with 65.4% of respondents indicating they were employed within the private sector. Most respondents (78.5%) were full-time salaried employees, with only 5.9% part time salaried, 6.3% self employed and 7.3% hourly contract employees.

2.2 Measures

The survey consisted of questions concerning demographic, organisational, professional and familial factors. All measures have been used in previous studies and were adopted because of their known high levels of internal consistency. *Work load* was measured using a 3-item scale adopted in a study by House, McMichael, Wells, Kaplan & Landerman [20] which had been used in previous studies. Respondents were asked how frequently they felt, from never (0) to very often (4), certain conditions within their job relating to speed, difficulty and time restraints. A higher score is indicative of a higher work load with a maximum score of 12. The alpha reliability for the sample was .84. *Work hours* was measured using a single items asking respondents how many hours they worked per week. *Work-family culture* was measured via a 20-item scale [19] that investigated three main areas: managerial support, negative career consequences, and organisational time demands. The co-efficient alpha reliability for each sub-construct was .86, .82 and .80 respectively. Respondents were asked to decide to what extent the statements characterised their current organisation using a scale ranging from strongly disagree (1) to strongly agree (7). It included items such as "In the event of a conflict, managers are understanding when employees have to put their family first". *Inter-role conflict* was measured via a ten-item, 7-point scale ranging from 1 (for strongly disagree) to 7 (for strongly agree), developed by Netemeyer, Boles & McMurrian [21] with the sub-constructs of work to family conflict, and family to work conflict. The co-efficient alpha reliability was .91 and .85 respectively. Items for each subscale were summed and high scores indicated a higher level of conflict. A sample item was "The demands of my work interfere with my home and family life". *Burnout* was measured using the 16-item Maslach Burnout Inventory (MBI) due to its brevity and proven reliability and validity of results. The MBI comprises three sub-scales evaluating emotional exhaustion (I feel emotionally drained from my work), cynicism (I have become less interested in my work since I started this job) and professional efficacy (At work, I feel confident that I am effective at getting things done). The items for the third dimension of burnout are framed in positive terms and thus a low score reflects a low sense of professional efficacy. Items were rated on a seven point Likert scale where 0 = never; 1 = A few times a year or less; 2 = Once a month or less; 3 = A few times a month; 4 = Once a week; 5 = a few times a week; and 6 = Every day. *Job satisfaction* was measured via a 14-item scale developed by Hackman & Oldham [22]. The scale tapped into specific facets of their employment such as their satisfaction with their pay, job security, social, supervisory and growth. Respondents were asked how satisfied or dissatisfied they were with different aspects of their job (1 for extremely dissatisfied to 7 for extremely satisfied). A sample item was "The amount of independent thought and action I can exercise in my job". The alpha reliability for each sub-construct was above .8, except for social which was .6. Overall job satisfaction was calculated using the mean value of all sub-scales. *Turnover intent* was measured via the two items on a scale ranging from 1 (for strongly disagree) to 7 (for strongly agree). A higher score reflected a higher likelihood of a person leaving their job. The alpha reliability for the sample was .79. *Work inflexibility* was measuring using a three-item 5 point Likert scale adapted from Hill, Hawkins, Ferris, & Weitzman [23] which focused on how much flexibility respondents had in deciding where and when their work was done, as well as how and what work was to be undertaken. Complete flexibility was rated 1 with a higher number indicating less flexibility. Mean inter-item correlations were calculated and found to average .38. *Life satisfaction,* which assesses an individual's perception of their quality of life in general, was measured using a five-item scale ranging from 1 (for strongly disagree) to 7 (for strongly agree) developed by Diener, Emmons, Larsen, & Griffin [24]. A sample item from this scale is "I am satisfied with my life." The scales's alpha reliability for the sample was .89.

3. Results

3.1 Statistical Techniques

Data were analysed using SPSS for Windows (version 12.1) and the results are presented in Tables 2 to 6. Factor analyses were conducted on two of the scales as they were known to be multi-dimensional. The factorial model for burnout was consistent with the Maslach Burnout Inventory yielding three factors; "emotional exhaustion (EE)", "professional efficacy (PE)" and "cynicism (CY)". These were retained and have been considered separately in further analyses. A three-factor work-family culture was found to be sustainable under confirmatory factor analyses, however five of the twenty items loaded more heavily on a different factor than that found by Thompson et al. (1999) when developing the scale. This original study's results did provide strong evidence that some sub-constructs were measuring part of the same underlying dimension which was confirmed in this study. It was therefore decided to use the same items for the factors as used by Thompson and her colleagues. These were "Managerial support (MS)", "Career consequences (CC)" and "Organisational time demand (OTD)". The alpha co-efficient for each was found to be greater than .8 indicating a good level of internal consistency of items used within the sub-constructs.

Bi-variate correlation analyses were conducted to assess the degree to which one variable is linearly related to another, thereby determining the direction and strength of linkages between variables. Multiple regression analyses were used to determine the main effects, in hypotheses H2 and H3, and whether factors suggested in hypothesis H4 and H5 were moderator variables. Moderator variables affect the "direction and /or strength of the relation between an independent or predictor variable and dependent or criterion variable" [25, pg1174]. This is illustrated in Figure 1 below. The moderator hypothesis is supported if the interaction (path c) is significant while the predictor and moderator variables are controlled. Procedures described by Baron and Kenny [25] were used to test for moderation effects. Prior to conducting any tests for moderation effects, all continuously measured variables were centred. This is achieved by subtracting the mean value for a variable from each score for that variable and eliminates problems associated with multi-collinearity.

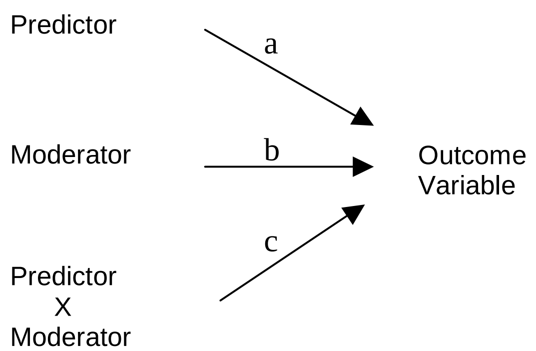

Figure 1: Moderator model [25, pg1174]

3.2 Descriptive Statistics and Bi-variate Correlations

The results (Table 2) indicate that civil engineers perceive their work load to be high and their organisations to be only very slightly supportive of employees with family needs with a mean item value of 4.69 for managerial support (MS), 4.41 for career consequences (CC) and 4.19 for organisational time demands (OTD). This represents a mean overall score of 4.5 (neutral was 4, slightly agree was 5). Work-family conflict (WFC) had a mean value of 22.04 which represents a mean item value of 4.41. This indicates that, in general, civil engineers feel they have a moderate level of work-family conflict with the mean score for WFC being above the mid point mark.

Table 2 also provides the bi-variate correlations between the variables measured in the study. These results are presented below and significant linkages are only described once. As hypothesised (H1) civil engineers reporting organisational values which were supportive of their work and family also reported lower levels of work-family conflict (r = -.410, r = -.331 and r = -.514; $p \leq .01$), greater levels of job satisfaction (r = .447, r = .396 and r = .292; $p \leq .01$), greater levels of life satisfaction (r = .366, r =.334 and r =.374; $p \leq .01$) and lower intentions to leave their organisations (r = -.375, r = -.325 and r = -.373; $p \leq .01$). In addition those that reported a more supportive culture also reported less work flexibility and lower levels of burnout particularly in the emotional exhaustion. Average work hours and work load were significantly and positively related to work family conflict and emotional exhaustion, indicating that engineers who work longer hours, or perceive their work load to be heavy, have greater levels of burnout and greater interference of work within their family domain. Interestingly greater workload was also positively correlated with job satisfaction.

Respondents who had higher levels of emotional exhaustion were also less satisfied with their job, had less work flexibility and greater turnover intentions. Engineers reporting greater levels of life satisfaction also reported significantly less work to family conflict. As expected there are also statistically significant correlations between work flexibility and the supportive workplace indicators. It should be noted that many of the measures of organisational experiences, satisfactions and well-being are themselves correlated (i.e. life satisfaction and burnout, life satisfaction and job satisfaction, etc.).

3.3 Tests for Direct Effects and Moderating Variables

To test hypothesis H2 to H5 a series of regressions were used. To test for moderating effects in H4 and H5 the independent variables were first entered in the regression and then the interaction of interest was added. The dependent variable of emotional exhaustion was first tested to ensure it did not differ by industry sector, age or gender. As no significant differences existed none of these variables were included in the regression analysis as controls.

Table 3 shows a main effect of work load and organisational time demands (OTD) on work family conflict supporting hypothesis H2.

Table 3: Multiple regression for work load and organisational time demands as predictors of work family conflict

	R^2	F	β
Independent variables			
Work load	.331	49.96	.272***
Organisational time demands (OTD)			-.420***

* p=< .05, ** p =< .01, *** p=<.001

The model explained 33.1 per cent of the variance in work family conflict. Of the two variable organisational time demands made the largest contribution (β = -.420) although work load also made a highly significant contribution.

Table 2: Means, standard deviations and intercorrelations for study variables

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Work hours per week	45.37	10.36	1												
2. Work Load	8.57	2.07	.440(**)	1											
3. WFCulture: MS	4.69	.93	-.235(**)	-.187(**)	1										
4. WFCulture: CC	4.41	1.12	-.193(**)	-.147(*)	.682(**)	1									
5.WFCulture: OTD	4.19	1.37	-.344(**)	-.347(**)	.658(**)	.640(**)	1								
6. Work to family conflict	22.04	7.01	.372(**)	.419(**)	-.410(**)	-.331(**)	-.515(**)	1							
7. Family to work conflict	15.08	5.96	-.080	.073	-.029	-.201(**)	-.115	.184(**)	1						
8. Burnout: EE	2.77	1.35	.229(**)	.377(**)	-.406(**)	-.371(**)	-.494(**)	.496(**)	.138(*)	1					
9. Burnout: CY	1.75	1.28	.016	.005	-.350(**)	-.327(**)	-.317(**)	.275(**)	.094	.536(**)	1				
10. Burnout: PE	4.48	1.07	.140(*)	.217(**)	.167(*)	.229(**)	.136	-.008	-.074	-.174(*)	-.380(**)	1			
11. Job satisfaction	5.23	.86	.031	.138(*)	.447(**)	.396(**)	.292(**)	-.206(**)	.091	-.293(**)	-.562(**)	.413(**)	1		
12. Turnover intentions	3.45	1.83	.076	.131	-.375(**)	-.325(**)	-.373(**)	.352(**)	-.030	.358(**)	.536(**)	-.247(**)	-.536(**)	1	
13. Work inflexibility	3.17	.96	.234(**)	.094	-.324(**)	-.266(**)	-.195(**)	.153(*)	-.138(*)	.297(**)	.309(**)	-.124	-.349(**)	.296(**)	1
14. Life satisfaction	22.41	6.69	-.119	-.127	.366(**)	.334(**)	.374(**)	-.306(**)	-.078	-.350(**)	-.430(**)	.300(**)	.553(**)	-.386(**)	-.246(**)

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table 4 shows a main effect of work family conflict on emotional exhaustion in the expected direction. Thus, hypothesis H3 was supported. The interaction between work family conflict and managerial support (MS), while approaching significance, did not have a significant effect on emotional exhaustion, indicating that managerial support does not moderate the relationship between work-to-family conflict and emotional exhaustion. However when the test was conducted for the male and female respondents separately (see table 5 below) managerial support did moderate the relationship between work family conflict and emotional exhaustion - but only the female sample. Thus hypothesis H4 was confirmed but for the female sample alone.

Table 4: Multiple regression for WFC and MS as predictors of EE for whole sample

Step	ΔR^2	F Change	β
1. *Independent variables* Work family conflict (WFC) Managerial support (MS)	.295	42.228	.398*** -.243***
2. *Interaction* WFC X MS	.012	3.456	-.113

* *p*=< .05, ** *p* =< .01, *** *p*=<.001

Table 5: Multiple regression for WFC and MS as predictors of E for male and female engineers

Step	Male			Female		
	r R^2	F Change	β	r R^2	F Change	β
1. *Independent variables* Work family conflict (WFC) Managerial support (MS)	.165	8.800	.284** -.206*	.404	36.993	.493** .493*
2. *Interaction* WFC X MS	.002	.159	.040	.032	6.047	-.186*

* *p*=< .05, ** *p* =< .01, *** *p*=<.001

Table 6 reveals that work inflexibility did significantly moderate the relationship between work family conflict and emotional exhaustion thus supporting hypothesis H5.

Table 6: Multiple regression for work family conflict and work inflexibility as predictors of emotional exhaustion (burnout)

Step	ΔR^2	F Change	β
3. *Independent variables* Work family conflict Work inflexibility	.296	42.407	.461*** .226***
4. *Interaction* Work family conflict X Work inflexibility	.020	5.809	.141*

* *p*=< .05, ** *p* =< .01, *** *p*=<.001

4. Discussion and Conclusions

The purpose of this paper was to explore the prevalence of work-family conflict and supportive organisational values experienced by civil engineers. The research found that civil engineers do experience moderate levels of work-family conflict and in general work in organisations that they do not perceive to be very supportive of employees' need to balance work and family demands. The profession appears to suffer a "cultural lag" with traditional values being considered the norm and consequently the ones rewarded (e.g. long work hours, full-time working). In this study 90 per cent of the sample worked at least 36 hours per week (the remaining ten per cent being predominantly female) and over 41 per cent of the sample worked over 46 hrs/week. This is occurring despite the fact that men are reporting an increased preference for more part-time work and less working hours [26]. While 56.1% indicated they were happy with the hours they worked; 41% of respondents indicated a preference to work less and only 1.5% wanted to work more. The study did not, however, support a preference for part-time work options. This may be related to the sample's low level of satisfaction with their current pay and benefits, compared to other facets of job satisfaction measured.

The paper also examined the relationship between perceptions of a supportive work family culture and job satisfaction, work load, turnover intent as well as life satisfaction and mental health. The data indicates strong positive correlations between a supportive work culture and job satisfaction. Job satisfaction is closely linked to affective organisational commitment which has been associated with higher productivity [27] and a more positive work attitude. The data also shows that if an organisation is perceived by employees to be unsupportive of work-family balance then turnover intent increases. Staff turnover has specific expenses in terms of costs relating to retraining, recruitment and lost productivity and the civil engineering profession must be careful that its members do not leave it in order to pursue careers that provide greater benefits. At a personal level those reporting a supportive culture also reported higher levels of life satisfaction and better levels of mental health. So from an occupational health perspective as well as from an organisational performance viewpoint the data provides evidence of the benefits of a supportive work culture.

The results also demonstrate the importance of a flexible supportive work environment. Work load and organisational time demands predicted 33.1 per cent of the variance in work family conflict. This result suggests that perceived work load, and the expectations that organisations place on the time employees should commit to the workplace, have the potential to indirectly influence turnover intentions through their effect on work family conflict. Organisations must therefore be cognisant of the expectations they place on employees if they which to retain staff. Work family conflict also demonstrated significant main effects on the emotional exhaustion dimension of employee burnout and flexibility was found to moderate this relationship. Burnout has been found to be associated with negative organisational and personal measures. Managerial support also moderated the relationship between work family conflict and emotional exhaustion for the female sample. These findings have important implications for management. Firstly they suggest that supportive managers and flexible work practices can be a preventative strategy for burnout caused by work family conflict. They also indicate that gender differences exist in the work family area and these need to be considered in the human resource management practices of organisations employing engineers.

In order to achieve a supportive culture, change must be driven from the top down and sensitivity training for middle managers and supervisors may also be required [5, 19, 15]. The provision of benefits delivered through human resources policies is not sufficient in itself and a workplace culture must exist within which employees feel comfortable taking advantage of alternative workplace policies [15, 19]. However, the change needed in engineering may not come easily. Indeed, however accepting of change they may be at the start of their career, male entrants inadvertently reinforce current attitudes and practices by emulating the behaviour of the managers who influenced their own career development [28]. Fielden and colleagues [29] also suggest that in the construction industry, a lack of compliance with cultural norms, such as refusing to undertake long hours, can adversely affect the promotion prospects of employees and even their job security.

It should be noted that while this study has revealed associations between work and family variables, being a cross-sectional study it is limited in its ability to determine causal relationships. Further analysis of the full dataset will be carried out to examine the effect of gender and family structure and investigate the presence and effect of work-life benefits currently available to civil engineers. It is hoped that this work will inform companies on these issues so they can develop policies that are suitable for their different employees.

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Labour Productivity in the building industry

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Abstract

The cost of labour in the building industry is in the region of 25 - 40 % of the cost of building. Hence the cost of labour is quite high and yet it is the main cause of variability in construction costs. The time used by workers on daily basis on productive activities averages about 30% of the total time available for construction work. The remainder of the time, i.e. about 70% is wasted on non-productive activities, delays and added activities. For a company in the building industry to remain competitive, it must try to improve the productivity of its labour. This paper reviews the literature on labour productivity in the building industry. It looks at the definitions, measurement, use, factors affecting and theories on improvement of labour productivity in the building industry. It is noted in the industry lacks generally agreed strategies for improvement of labour productivity. The paper further reviews the paradigms of innovation, benchmarking, and industrialization among the theories aimed at improving the productivity of labour in the building industry.

Key words: Labour Productivity, Building Industry.

1. Introduction

1.1 Background

The construction sector has a strategic role in all developing and developed countries. The construction industry is the single largest industrial employer in Europe employing more than 7% of the labor force (Proverbs, Holt and Olomolaiye[1]). According to Uganda's Ministry of Finance in Uganda [2], the construction industry contributes 12% of the Gross Domestic Product (GDP) and employs 5% of the registered workforce in Uganda.

In most developing countries, labor-intensive production is still in use in the construction sector and this situation will remain for a couple of years to come.

According to Buchan, Fleming and Kelly [3], Zakeri, et al [4] and Kaming et al [5], Gilleard J. [6] labor cost is somewhere between 20% and 50% of the total project cost. Hence the reduction of labor and therefore construction costs can be best carried out by labor productivity improvement. Productivity is the key to greater competitiveness, as it is critical to the profitability of most construction projects.

The time used by workers on daily basis on productive work averages about 30% of the total time available for construction work (Jenkins, [7]). At the same time, low productivity has led to high labour costs in comparison to the construction costs.

As pointed out by Yates and Guhathakurta [8], labor productivity is becoming an increasingly important topic to members of the construction industry. The problem of low and decreasing labour productivity appears in many other countries. For example, Teicholz [9] found out that labour productivity in the United States has continued to slowly decline (with a few exceptions) over the past 25 – 30 years. The important topic addressed in the Emerson report (1962), the Latham report [10] and the Egan report [11] is the issue of productivity in the construction industry.

1.2 Definitions

Different people have been using the word productivity to mean different things. Productivity is defined by Calvert el at [12] as the ratio of outputs to inputs. Labour productivity is one of the partial factors of productivity. It has been defined as the ratio of the total output to the labor input (Gilleard, [6]). Noor ([13]) defines it by the following equation

$$Labour.productivity = \frac{unit.output}{labour.manhours}$$

The determination of output is a relatively simple task, as they can be physically measured. As pointed out by Noor [13], the determination of labour workhours associated with measured output is a more contentious issue because it can be a measure of different input times. Different measurements of input times will give rise to different productivity measurements.

Labour productivity measured in terms of the paid time provides useful information to contractors for scheduling and estimating purposes on future projects. On the other hand, labour productivity measurements based on time available for work help to provide the basis for analyzing the effects of adverse weather conditions on labour productivity. Labour productivity measures that are based on productive time help in determining the effect of various factors on productivity such as constructability and delays due to lack of materials and equipment.

The measurement of output suffers from the non-standardization of the construction industry. For example, even concreting which can be measured in cubic meters has several factors influencing its productive time. The quantification of quality and increased use of prefabrication complicates the quantification of labor inputs also. There is need for the industry to agree on the way to measure the inputs.

2. Use of labour productivity

Productivity is one of the key measures of construction performance. Latham [10] and Egan [11] clearly addressed the importance of raising productivity in the construction industry in UK. The studies and the recommendations made for the UK construction industry are relevant worldwide. It was observed by Kaming and Olomolaiye [14] that poor productivity of construction craftsmen is one of the most daunting human resource problems in developing countries.

As pointed out by Kaming et al [5], the success of a construction company in today's competitive environment largely depends on accurate estimation of productivity.

Labour productivity rates are used as indicators of the construction time performance. They are used in planning and scheduling of construction, controlling of the cost and worker performance, estimating and accounting.

If a company wishes to reduce risk, increase profits, or gain market share, there is direct need within the firm to have accuracy data on and use of labor productivity (Gilleard [6]).

Although studies have been made in a number of countries, most of the data available is not directly relevant to all countries because of the differences in materials used, techniques employed and working environment. Construction workers too have differences in the work culture.

3. Methods of obtaining labour productivity

Before productivity can be increased, there is need to measure and quantify the existing situation. Lord Kelvin's dictum 'to know properly you must measure it' is sound advice to anybody interested in measuring productivity. The measure of construction productivity is thus a very important issue.

There are two different methods of generating data on productivity – accountancy based and engineering based methods.

Accountancy based standards rely on the analysis of historical accounting data to establish work-hour requirements for specific types of work. Engineering based standards involve breaking down complex work processes into small manageable parts and analyzing these parts for the length of time required to complete these processes. The accountancy-based data are relatively easy to follow but they do not capture the varying working conditions.

The engineering methods of measuring labor productivity include work measurement, work sampling, time and motion analysis, and modeling.

Work measurement is the determination of the time required for an average operative to carry out a particular task in accordance with a specified method and standard of performance (Calvert, [12]). Work sampling involves observing individual pieces of the work process and classifying the results as either productive or non-productive. It is useful for recording productivity levels for comparative purposes. Harris and McCaffer [15]) describe its use. Thomas [16] roundly condemned activity sampling as being unsuitable for measuring productivity in construction activities.

Time and motion studies are said to be the most accurate methods for generating productivity standards. Factor based modeling is arguably the most applicable engineering-based technique to the construction industry and has the potential to produce useful data. The factor model technique has been recommended by a number of authors (Gilleard, [6]) although it is yet to be accepted internationally.

4. Factors affecting labour productivity

Factors influencing productivity of construction workers in many countries have been explored (Borcheding, [17]). Gilleard [6] acknowledges that labor productivity figures are highly variable, affected by such factors as the mode of employment, overall task duration, and length of the workday.

Identifying and evaluating the factors that influence productivity are critical issues faced by construction managers (Motwani et al [18]).

Most of these factors have been arrived at my asking the workmen directly and the project managers. Borcherding [19] recognized that the best means of acquiring information about production problems is by asking the workmen themselves.

The common factors influencing construction productivity have been listed by Yates and Guhathakurta [8], Keone [20].

According to Keohn [20], productivity is related in part to the following variables: management (proper planning, realistic scheduling, adequate coordination, and suitable control); labour (union agreements, restrictive work practices, absenteeism, turnover, delays, availability, level of skilled artisans, and the use of equipment); government (regulations, social characteristics, environmental rules, climate and political ramifications); contracts (fixed price, unit cost, and cost plus fixed fee); owner characteristics; and financing.

The factors affecting labour productivity can be summarized under the categories of design, manpower, management, environment, and others.

Design issues including: design complexity, design changes, and quality.

Manpower issues including: worker motivation, skills of the workers, recruitment of workers, recruitment of supervisors, absenteeism, labour turnover, communication problems, labour disruptions, alcoholism, stoppages because of work being rejected by consultants, stoppages because of disputes with owners/consultants, stoppages because of insolvency, labor composition, overcrowding.

Management issues including: material shortages, delays in materials delivered to site, disruption of power/water services, stop-work orders because of accidents, site congestion, site layout/access, construction method.

Environment including harsh working conditions and others including construction volume, regulatory requirements, economic conditions, social factors

According to Burton [21], companies should only track the important activities. Rosefielde and Mills [22] argued that any measure of construction productivity that does not account for the changes in design and quality would lead to low, if not negative, measures of construction productivity.

5. Current theories for improvement of labour productivity

The current thinking that will improve construction productivity hinges on the theories of innovation and knowledge transfer, benchmarking and industrialization. Motwani, Kumar and

Novakoski [18] however pointed out that theories of improving productivity vary from business to business and because of the variety of uncontrollable productivity influence factors it is hard to have one plan.

5.1 Innovation

The performance of the construction industry in terms of productivity, quality and product functionality has been low in comparison to other industries, and a low rate of innovation has been provided as the major explanation to this situation (Winch [23], Gann [24]). As stated by Winch [25], construction is commonly characterized as a backward industry, one that fails to innovate in comparison to other sectors. While the other sectors modernized through the introduction of interchangeable parts, then assembly lines, and then automation, construction retained its craft method of operation and fell further and further behind the rest of the manufacturing industry in terms of productivity, quality and hence value for money.

Innovation is a process of gaining and using new and existing knowledge to enhance either a product or process (Dodgson and Bessant [26]). Freeman [27] defines innovation as the actual use of a nontrivial change and improvement in a process, product or system that is novel to the institution developing the change. Innovation as defined by Barret and Sexton [28] is the effective generation and implementation of a new idea which enhances overall organizational performance. The main factors for innovation include: reward for innovation; opportunity for innovators to communicate their knowledge directly by presentation of events; funding and support the industry Research and Development (R&D). The adaptation of new procurement methods and the new organizational structures are seen to improve the ability to provide more integrated and innovative solutions.

The industry requires radical changes if improvements in quality, productivity and performance are to be achieved. The construction industry is increasingly being challenged to successfully innovate in order to satisfy better aspirations and needs of society and clients, and improve competitiveness (Latham[10] and Egan [11]).

As pointed out by Motwani, Kumar and Novakoski [18], improving communication skills, preplanning and stricter management could help to raise the individual productivity rate from an average of 32 per cent productive time per hour to almost 60 per cent per hour.

It is important that the Construction Industry adopts TQM if it is to improve productivity since TQM is about changing attitude and skills so that the culture of the organization becomes one of preventing failure and doing things right first time all the time (ISO [29]).

A framework for improvement of productivity would address innovation of remedial measures such as recruiting and training a younger generation to have necessary skills, process improvement, standardization, and transfer of knowledge within the industry. The focus should be on continuous upgrading the management and technical skills of supervisory staff.

Barret and Sexton [28] acknowledge that although construction firms have always demonstrated an ability to innovate, construction practioners are now very much getting to grips with the need for and management of innovation as an explicit endeavor.

5.2 Benchmarking

Before productivity can be increased, there is need to measure and quantify the existing situation. The point made is that a construction company should have a measurement procedure in place such that it can determine how it is doing relative to the benchmark. As pointed out by Adrian [30], by measuring the company's performance relative to the benchmark and by implementing improved processes and procedures, the construction industry can work towards improvement.

Benchmarking is the search for the best practices that will lead to superior performance of an organization (Camp [31]). Houston in a document titled Planning, Organizing and Managing Benchmarking: Users Guide, defines benchmarking as a systematic and continuous measurement process of 1992; a process of continuously measuring and comparing an organization's business process against business leaders any where in the world to gain information which will help the organization to take action to improve its performance.

As early as in the 1800's, Fredrick Taylor's work on the application of the scientific method of business had encouraged the comparison of work processes. This was within the concept of benchmarking.

As Lema and Price [32] point out, there is need to explore the potentials of benchmarking for performance improvement in the construction industry. The construction industry can learn from the wealth of experiences available throughout the manufacturing industry. A common understanding of benchmarking has to be reached, and a conceptual framework that would cater for the industry's primary objectives at various levels has to be developed.

Lema and Price [32] point out that benchmarking is seen as a perfect vehicle to ensure that the customer gets the best quality under competitive conditions that ensure lowest prices. The three key roles of benchmarking are: to widen the competition base by exposing internal organizational processes to external market forces; accelerate the TQM process and therefore increase efficiency by providing the opportunity to learn from others, adopt and improve; and act as a tool for cooperation to improve overall industry performance. The preconditions for successful applications include: the need for performance improvement; the recognition and acceptance that there are lessons to be drawn from others that can lead to improved performance; the willingness and capability to change for better performance; and the accessibility to the best practices. The problem with the construction industry is the lack of initiative to make full use of benchmarking to create change.

5.3 Industrialization of construction

Increasing heavy demands for the products of the building industry were made in the years following the end of the Second World War during the reconstruction programmes. Since the Second World War, the world population has more than doubled. Currently, the demand on housing is very high and the number of homeless people has been growing. There is also a big number of huge construction projects, which are being undertaken notably in Eastern Asia and China. While the increase in demand of construction products is happening, there is growing shortage of skilled manpower. Shortage of manpower is unlikely to improve to any significant extent (Foster [33]).

Industrialization of construction is needed to increase the productivity of the industry generally while at the same time reducing the amount of site labour involved. Industrialization involves the rationalization of the whole process of building (which includes the process of design, the forms of construction used and the methods of building adopted).

Foster [33] defines industrialization as essentially an organizational process – continuity of production implying a steady flow of demand; standardization; integration of the different stages of the whole production process; a high degree of organization of work; mechanization to replace human labour wherever possible; research and organized experimentation integrated with production.

There is need to industrial all sectors of the construction industry if we are to satisfy the current demands. Ideally housing would be easier to provide for using industrialization in construction because most of the spaces and products can be standardized as exemplified by the precast concrete box units (Hansson [34]). Variations would only cater for special cases. The industry requires radical changes if improvements in quality, productivity and performance are to be achieved (Latham[10] and Egan[11]). Currently the industry is fragmented and has many stakeholders who are not well coordinated. Product and process industrialization would help to improve the situation.

Since the second world war, the idea of industrialization has received much attention both in Europe, North America and elsewhere. However, in spite of a great number of attempts, there has been a relative lack of success of industrialized building methods (Warzawski [35]). The share of prefabricated components has risen, and there are examples of advanced industrialization, notably the Japanese house producers (Gann [24]) and the American metal building providers (Ellifritt and LaBoude[36]) but a wider breakthrough for industrialized construction has still not occurred. According to Warzawski, the main problem of prefabrication of today in the lack of a system approach to its deployment on the part of the various parties involved.

The building construction industry still lacks in being rational. This is manifested by poor labour productivity due to lack of integration of design, poor supply chain management, on site fabrication and assembly with many inefficient processes.

6. Conclusions

It is has been noted that the industry lacks generally agreed ways of measuring and strategies for improvement of labour productivity.

It can be concluded that there are many factors that affect labour productivity and their effects vary from one industry to another. There is need to quantify the effects that those factors have on labour productivity so that remedial measures are sought. Although a few have been explored in specific industries, there are still many gaps to be filled in this area.

Although the literature indicates that the theories on innovation and knowledge transfer, benchmarking, industrialization in construction can be used to improve on labour productivity, there is still need to develop strategies on how they can be used. There are gaps on the relevance and application of the theories to improve labour productivity.

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Good Practice People Management through Human Resource Information Systems (HRISs)

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Abstract

Project organisations require extensive knowledge about their human resources in order to make informed and timely deployment decisions in the fast moving and highly competitive market place. One of the contemporary trends within strategic human resource management (SHRM) has been the application of human resource information systems (HRISs) as support tools for managerial decision-making. This technology has the potential to greatly enhance an organisation's ability to collect, store and utilise personnel data. Traditionally, construction organisations have been characterised by the older 'personnel' style people management practices and low take-up in technology. However, a recent EPSRC funded study of large UK-based construction contractors' SHRM practices found that many industry leaders in the country are beginning to utilise the potential of HRIS technology. An early survey (Raidén *et al*, 2001) indicated approximately 65% of these organisations to use computer applications for HR related functions. This paper reports the results of further research which explored the utilisation of such technology within seven case study organisations representative of the largest UK construction firms. Although the research revealed many innovative practices, none of the companies were found to adopt an integrated approach to SHRM-operations collaboration. Accordingly, an agenda for further development in the area is suggested. This promotes the strategic integration of the organisational and human resource planning, team deployment, performance management, human resource development and employee involvement activities which are central to effective human resource and project management.

Keywords: strategic human resource management (SHRM), human resource information systems (HRISs), team deployment

1. Introduction

The project-based nature of construction work requires firms to set up temporary organisational structures at dispersed geographical locations [1]. Work in this context is rarely ongoing and repetitive activity. Resources are transient and change is constant [2]. The project team forms the central working unit in this setting. Hence, the characteristics of staff allocated to project teams has a crucial effect on the success of an organisation. Accordingly, project-based organisations, such as construction contractors, require extensive knowledge about their human resources in order to make informed and timely team deployment decisions, particularly in the modern fast moving and highly competitive market place.

Strategic Human Resource Management (SHRM) provides an influential approach to the management of people in many business sectors [3]. It comprises a set of practices designed to maximise organisational integration, employee commitment, flexibility and quality of work [4]. This is achieved through integrated employment relations, Human Resource Development (HRD) and employee resourcing functions. Employment relations provide the overall philosophical framework for organisational culture, policy and practices. HRD focuses on individual and organisational learning and development. Employee resourcing comprises of the staffing, performance management, HR administration and change elements of SHRM [5]. The staffing activities include Human Resource Planning (HRP), recruitment and selection, and team deployment. Performance management includes employee appraisals and career development. The HR administration function consists of the collection, storage and use of employee and organisational data in support of HR monitoring and analysis. One of the contemporary trends in employee resourcing has been the application of Human Resource Information Systems (HRISs) as support tools for managerial decision-making and HR administration. This technology has the potential to greatly enhance an organisation's ability to collect, store and utilise personnel data.

Traditionally, construction organisations have been accused of adopting 'personnel management', rather than the modern SHRM style people management practices. However, more recently many industry leaders in the UK have begun to use HRISs [6]. A recent survey [6] indicated relatively widespread investment in such technology but also found that the system capabilities were rarely exploited to their full potential. This paper reports on the in-depth follow up on the survey findings. Initially, HRISs and current literature on construction people management are reviewed. This is followed by an explanation of the research methodology and discussion on the findings and results of the study. The paper concludes by suggesting an agenda for further development in the area.

2. Human Resource Information Systems (HRISs)

'Human Resource Information Systems' (HRISs) is the term used to refer to a particular type of hardware and software that is aimed at supporting the SHRM function within organisations. Broderick and Boudreau [7] define HRISs as a:

> *"composite of databases, computer applications and hardware and software that are used to collect/record, store, manage, deliver, present and manipulate data for human resources".*

In short, HRISs provide an electronic database for the storage and retrieval of employee data that offers the potential for flexible and imaginative use of this data [8]. Two main types of IT applications suitable to HR needs are:

1) *Transaction processing/ reporting/ tracking applications* best suited to support routine high volume HR decisions;

2) *Expert systems* which seek to improve decisions through rules derived from careful analysis of expert decisions over time, and decision-support systems that seek to improve decisions for which the rules are changing or are not well defined, and the right outcomes are unknown [7].

While some of the HRISs available are simply sophisticated database applications, an expert system incorporates artificial intelligence into the system, thereby increasing its learning capabilities. It solves problems by heuristic or approximate methods, which do not require perfect data. Thus, expert systems have the benefit of being able to propose solutions with varying degrees of certainty [9]. Other significant benefit of an expert system is that its workings are transparent: the system is capable of explaining and justifying solutions or recommendations in order to convince the user that its reasoning is correct [9].

The uses of HRISs range from automating basic data management tasks, through to enabling managers to integrate their business objectives with the SHRM priorities and providing employees with self-service functionality [8]. Table 1 differentiates between the two, automating and informing.

Table 1: Uses and benefits of HRISs (after Tansley et al [8]*)*

Automate	**Inform**
Use of the system	
Electronic filing cabinet	Sophisticated database/ expert system
Enables storing and analysis of employee data	Enables managers to act on HR information
Support more effectively direct control – employee activities and productivity transparent to managers	Assumes a philosophy that the system itself and appropriate managers can make decisions – provides access to comprehensive range of information
Facilitate close supervision and monitoring	Facilitates empowerment and indirect control
HR access	Employee self-service
Benefits	
Task mechanisation – can save mental and/ or physical labour in data management	Can transform HR practices
Process automation – can enable greater efficiency of HR practices	Can enable managers to integrate their business objectives with HRM priorities
Cost reduction (in reduced overheads)	Cost reduction (in reduced overheads)
Improved HR service: faster service, improved quality and consistency of information	Availability and accessibility of wide range of information

Table 1 highlights a fraction of the key functionalities of HRISs and their associated benefits. Many writers and professional practitioners have recognised the substantial benefits that HRISs can bring to the efficient management of the HR function [7, 10-17]. The systems have particular capabilities for managing staffing, HRD, performance, reward and HR administration [18-22]. They can help HR professionals to improve productivity, control employee benefits, streamline compliance with HR legislation, manage the payroll function, and lower the costs of employee resourcing [23]. As outlined in Table 1, in essence they automate daily administrative HR tasks, integrate cross-departmental activities and ensure the accuracy and consistency of employee records.

Recent developments have led to HRISs having the potential to hold comprehensive databases of employee skills and qualities, including their future aspirations, and produce complex reports mapping the employee abilities and preferences against forthcoming vacancies/projects [24]. The latest generation of web-enabled HRISs now also allow employees to update their own personnel records, submit timesheet data, review benefits, request holidays and enrol on training courses [25]. This integration of so many key SHRM activities can facilitate both the recruitment and retention of staff by delivering automated features and quantifying the value of total compensation packages [19-21]. However, the key espoused benefit of automating SHRM processes is that it leaves HR professionals and line managers more time to focus on strategic activities, and provides information for them to be able to turn their employee assets to a source of competitive advantage [23, 26]. Thus, HRISs have the potential to revolutionise SHRM by providing up-to-date information, services to employees, return on investment, and strategic analysis and partnership [10, 23, 27].

Information Technology (IT) is often seen as an effective stimulus for achieving transformational change. For example Davenport [28] argues its role as both an enabler and an implementer of process change. Similarly, Tansley *et al* [8: 364] concluded:

> *"…introduction of the HR system could potentially provide the stimulus to actually effect the required change in employee management practices…"*

Thus, the use of HRIS technology could help in developing the construction industry's people management practices from the older 'personnel' toward SHRM. However, despite the numerous benefits HRISs can offer, extensive debate exists in relation to the profitable implementation and application of HRISs in practice. According to Tansley *et al* [8], much of the success depends on nine key factors including: Senior management support and commitment; Involvement of representatives from all potential user groups in the project team (e.g. senior managers, HR, IT, line management, employees); Provision of comprehensive range of information on both on the potential system(s) and their potential benefits; Suitability of the potential system to the industry/ sector of work and the specific challenges its environment places; Suitability of the system to the organisational culture(s) and management style; Differences of operating systems/ approaches within different organisational divisions – need for integration/ business process review and redesign; Benefits vs. costs; Potential uses of the system (automate/ inform); and the relationship between HR and HRIS strategy and policies. Accordingly, the consideration and implementation of HRISs must take into account a wide range of factors if maximum benefits of the technology are to be achieved.

3. The challenging context of the construction industry

As suggested above, HRISs offer the potential to support construction industry project management and culture transformation. In relation to project management, this needs to focus on the integration of the individual needs, preferences and requirements of employees' with the achievement of project/ business objectives by suggesting optimal solutions to particular resourcing requirements. In terms of culture transformation, HRISs could help in moving industry practices toward integrated and sophisticated employment relations, HRD and employee resourcing activities forward from the traditional 'personnel' view of legislative compliance. This could have long-term benefits in relation to the retention and development of staff in the industry overall, and hence in meeting the future succession management plans of the organisations in the industry. However, although HRISs are widely used to support SHRM within other sectors [5, 29, 30], the ways and levels of practice within construction organisations vary greatly [6].

Raidén *et al*'s [6] earlier survey explored the use of HRISs in the 100 leading construction companies in the UK. The postal questionnaire asked their use of information technology applications for SHRM related functions; which HRIS application, if any, they used; the lengths of time the system had been in place; the functions for which the HRIS was used; and how satisfied they were with the system. The results suggested that the use of computers for HR information in construction is broadly similar to the national average. However, the utilisation of such systems was identified as being extremely limited, restricted to routine administrative tasks. Employee records (82.2%) and reports and enquiries (68.9%) were most commonly cited functions followed by training and other HR administration, such as annual leave, pensions and attendance monitoring, at 40-50%. Only one third (33.3%) of the respondents said to use HRISs for managing appraisals and one fifth (22.2%) for staff deployment. This was despite the extensive capabilities the systems offer for supporting complex collection and retrieval of data and decision-making. However, as a result of the analysis of user satisfaction with the HRIS applications, it appeared that the more 'advanced' or strategically focused the activity the higher the user satisfaction rating [6]. This was concluded to infer that the companies that do use HRISs for complex SHRM tasks derive considerable benefit from their application. Furthermore, this could suggest that the complex and dynamic resourcing environment that the construction industry presents is well suited to the application of IT-based systems.

Loosemore et al [31: 109] identified the key advantages of using a HRIS to support SHRM decision-making in construction to include:

- Easier provision of information to line managers, thereby enabling rapid resourcing decisions during projects;

- Easier processing and control of employee records and performance data linked to reward systems (i.e. removing the need for managers to maintain unwieldy paper-based systems); and

- A reduction in the workload of the personnel function, thereby lowering the head office overhead associated with the SHRM function.

Ng et al [32] modelled an HRIS for Australian construction companies. They drew on the work of Patchett [33] who identified the major construction activities that require HR information as manpower planning and development, payroll, labour control, safety management, industrial relations and compensation and benefits. This approach seems limited in serving the full range of SHRM information requirements within construction companies. Numerous studies have also focused on developing generic scheduling support, cost control and information and project management models/ systems for the construction industry [34-39]. By combining these approaches to work scheduling and project management with an HRIS and optimal solution may be identified, although barriers to the process may present the industry's limited trust and confidence in IT systems [40-42].

4. Research methodology

Following detailed analysis and publication [6] of the HRIS survey results, an in-depth follow up on the findings was conducted via semi-structured interviews in seven case study organisations representative of the UK market leader. Table 2 lists the type of participating organisations, their main operating sectors and annual turnover at the time of the research interviews: 2001-2002. 'National contractor' refers to an organisation with its headquarters in the UK. This distinguishes case studies A-E and G from F, the 'European contractor', whose headquarters are located in Holland.

Table 2: Case study organisations

	Case study	Sector	Turnover (£'000s)
A	National contractor	Building	1,074.000
B	National contractor	Civil engineering	487.238
C	National contractor	Civil engineering	1,680.000
D	National contractor	Building	1,382.200
E	National contractor	Civil engineering	1,335.900
F	European contractor, UK branch	Building	706.000
G	National contractor	Building	649.000

The interview sample included divisional directors (*n=4*), operational senior managers (*n=9*) and HR staff (*n=11*). The data was tape-recorded, transcribed verbatim and analysed using NVivo qualitative data analysis software and summary statement matrices. This provided a robust but flexible methodology for reporting and analysing the case study organisations' approaches and techniques on good practice people management with dual benefits. Firstly, the results of the study can help other organisations in the industry to evaluate and improve their take on personnel/ SHRM and thus, can contribute to the improvement of the culture in the industry overall. Secondly, the research adds to the limited body of knowledge that currently exists on the industry's people management practices, particularly in relation to employee resourcing and HR administration [43]. The following section outlines and discusses the main results and findings before the conclusions, which suggest an agenda for further development in the area.

5. Results and discussion

The interviews highlighted several areas of SHRM in which HRISs were utilised to support managerial decision-making and HR administration. These included Human Resource Planning (HRP), recruitment and selection, team deployment, performance management and HR administration.

5.1 Human Resource Planning

A particularly successful HRP technique was found in company C, which operated a quarterly human resource planning schedule. Key managers met regularly to discuss the HR requirements for the following quarter in relation to the forthcoming workloads. Staff availability charts drawn from a resource management database were used as an information source for the meetings. This type of planning process was said to be particularly useful in identifying and balancing peaks and troughs in staffing requirements. Although the quarterly schedule represents a relatively short-term outlook on staffing issues, the system helped the organisation to introduce structure to the process and reduce the uncertainty inherent within the industry's staffing practices. The HRISs application (resource management database) clearly provided a crucial information source, and thus acted as a decision-support tool.

5.2 Recruitment and selection

Company C also focused on internal recruitment and promotion via the company Intranet. All vacancies were advertised in the HR facility and staff were regularly encouraged to access the available information. This provided transparent progression and development opportunities, which encouraged long-term commitment to the company. Information technology provided the main communications channel, via the company Intranet, and helped to link resourcing activities with the HRD element of SHRM.

5.3 Team deployment

Company B had recently restructured its operations to form two separate divisions comprising a regionalised and national business. Within the national businesses, HR personnel managed deployment via a central resource bank which members of staff could voluntarily agree to join. The central resource bank consisted of an employee skills database, which recorded the members' experience and qualifications. Use of such a database helped the company to ensure that only personnel willing or keen to travel were deployed to projects beyond the regional boundaries. This was particularly useful in managing work-life balance issues.

Company C also utilised their resource management database to inform team deployment. The system catalogued employees' job titles, previous experience and projects, line manager, etc. Availability charts provided a basis for decision-making which was supported by secondary criteria, such as appraisal records, career development needs, location, salary package and clients. All this information was held within the single database, and thus easily accessible.

Company D operated a particularly effective approach to the team deployment process. In creating a team, four main sources of information were drawn together to form a comprehensive picture of a potential team members' suitability for a project:

- technical competence (from job descriptions, experience summary sheets and chartered status records)
- personal development assessment (to support technical competence evaluation and provide information on personal aspirations, needs and preferences)
- personal relationships (line managers' subjective knowledge on how the employee works with other people/ as part of a team)
- time (employee availability re: current project/ commitments, potential disturbance of a move mid-project).

Clearly, computer hardware and software applications played a central role in the process. Technical competence data, employee development records and time information were all sourced through a HRISs. Only the managers' subjective accounts of employees' team working skills were not included in the system, although many modern HRISs can act as repository for such data.

5.4 Performance management

Company C's performance management system was geared towards providing information for their resource management database discussed above. This was seen as an effective tool for encouraging employee involvement as it integrated the employee needs and preferences highlighted within the appraisal system with the HRP, team deployment and other related employee resourcing activities. For the organisation the system provided information managers and HR personnel could use to identify high flyers and potential succession planning candidates, individual and organisational competencies and capabilities, and how well their employees shared the company values.

Within their very strong hierarchical structure, company D operated a particularly innovative approach to career management. The company Intranet had a career “route map”, which clearly showed the options available from each post. Links to job descriptions outlined the minimum and outstanding requirements for each role. These were used to aid discussions on aspired and realistic future moves. They formed a practical tool for benchmarking performance against desired criteria and identifying training and development needs. The success of the Intranet ‘route map’ was clear; the careers section was the most popular site within the whole of the company intranet.

5.5 HR administration

At the time of the research interviews, companies A and E were in the process of developing in-house HRISs. In company A this was to form a complete HR database for the group and hold all basic personnel data, such as employees’ addresses, dates of birth, job titles, absence records and holidays. Inclusion of training and development aspects was planned for the future. Ideally, the system was to include everything the organisation need to know about their staff. Despite this, reporting labour/ staff turnover and absence, and ethnic monitoring were seen as the main applications for the system. HR specialists currently manage all HR administration, therefore, it was presumed that they would carry this on but in the future using HRIS. Potentially, such a comprehensive HR database is capable of informing human resource planning, recruitment and selection, team deployment, HRD and other SHRM related planning and decision-making.

In company E the internal HRP information system under development was envisaged to include facilities for comprehensive data management and decision-support. The system was to replace the current divisional databases and provide a centralised information source for the group as a whole. It was to run separately from the group’s personnel database, but with capabilities for data sharing between the two. The HR department assumed overall responsibility for maintaining the HRP information system as well as the personnel database.

In company G some of the HR information was currently recorded and stored within computerised systems, but these were operated in isolation from each other. For example, a bespoke database had been developed to hold employee records at a company-wide level, but training and development data was held on a separate system administered at a divisional level. Payroll details were held on yet another system held by the personnel department. This resulted in several members of HR and operational staff having to be involved in any SHRM related decision and the information being transferred across multiple systems. This did aid inter-departmental collaboration, however, when discussing the possibilities of introducing a HRIS, several managers felt this would prove useful in reducing their administrative workload. Others suggested that it would be useful in promoting movement across divisions when demands on the business required it. This confirms Tansley *et al*'s [8] contention that a HRIS potentially provides a stimulus for changing in employee management practices.

6. Conclusions

This paper has explored the use of computer applications for SHRM functions in construction organisations. On the basis of the survey findings and an extensive literature review, the advantages of HRISs to the effective and efficient management of the people management element of construction operations has been supported. In particular, it offers the potential to greatly enhance the organisations' ability to collect, store and utilise personnel data to support managerial decision-making. The benefits were also highlighted to include increased employee involvement and integration of the resourcing and HRD aspects of SHRM. The research recorded many innovative practices on HRP, recruitment and selection, team deployment, performance management and HR administration. For example, Company C had particular strengths in HRP, recruitment and selection, and performance management, whilst Company D had devised a sophisticated team deployment function. However, despite the wide range of good practice found within the case study companies, none of the participating firms were had adopted a fully integrated approach to SHRM-operations collaboration. Accordingly, an agenda for further development in the area is proposed to include wider reaching development of the research project. This would help determine the applicability of the findings to a larger population and also potentially lead into the refinement of a tool developed to support the holistic management of the resourcing function. A Strategic Employee Resourcing Framework (SERF) [1] would promote the integration of the organisational and HR planning, team deployment, performance management, HRD and employee involvement activities that are central to effective SHRM and project management. The potential of this framework to revolutionise employee resourcing, and in particular the HR administration function, in the industry through the careful application of sophisticated modern HRIS software is significant [8].

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The Demand for Labour in Construction

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Abstract

The construction industry narrowly defined involves only those firms directly involved in the erection of structures and other constructed facilities, but this is part of a wider construction sector that involves all of those aspects of the business from obtaining the raw materials through to demolition and disposal of the facility at the end of its useful life. Statistics on construction normally only focus on the narrowly defined industry, but still suggest that it is a major contributor to the national economy and to employment in particular. However, the statistics also fail to take account of two other important aspects of the industry and these are the informal sector and the work done by ‘direct labour organisations’ (including do-it-yourself and mutual aid). Estimates of the scale of the broadly defined sector as well contributions of these aspects of overall construction are examined to give an overview of the full impact of the sector on employment in the economy.

Keywords: formal, informal, direct labour, employment, construction sector.

1. Introduction

There is some dispute over the causal relationship between economic expansion and the construction industry i.e. whether construction tends to be pulled by or is pushing the national economy[1]. In most developing countries, however, the problem is a weak local construction capacity and inefficiency at all levels. Whether it pushes or is pulled, however, the construction sector is important because it is responsible for infrastructural development, construction of utilities and service facilities, houses and new buildings, repairs and maintenance, for example, all of which are ongoing activities regardless of whether the economy is in a boom or bust state.

One of the major objectives of development policy is not only the creation and expansion of production capacity, but the generation of employment opportunities to accommodate a changing labour force. Thus, in developing countries, construction is not only key to the modernization process, but its labour intensive nature makes it particularly attractive as a means of creating employment. It is also a valuable training ground for technicians, managers, craftsmen and entrepreneurs who are essential for the growth of any economy. Trinidad and

[1] Drewer [1] argues that the central problem is to remove those constraints on development which are a consequence of the ‘lack of fit’ between an economy’s demand for construction and its capacity to absorb construction output. An efficient indigenous construction capacity is an integral part of social and economic development.

Tobago (T&T) is a small, open, oil and gas based economy that, perhaps more than most, has experienced the effects of boom and bust and the associated fluctuations in income and employment. This paper focuses briefly on the behaviour of the construction industry in times of economic expansion and contraction, before going on to look at the more broadly defined construction sector.

2. The Trinidad and Tobago Economy

The economy of T&T since the early 1970s has cycled from boom to bust largely in time with the price of oil. Increased oil production together with sharp increases in oil prices after the Organization of Petroleum Exporting Countries (OPEC) intervention between 1973 and 1981 ushered in a boom period for T&T with government's current revenue increasing from US$233 million in 1973 to US$2,762 million in 1981. Real GDP grew at an annual average rate of over 5% per year, and real per capita GDP increased by 45% over the period. The unemployment rate fell from 15.4% in 1973 to 10% in the early 1980s. Construction's contribution to GDP rose from 7% to 16.1% over roughly the same period.

During this boom period, in the late 1970s, the construction sector began to show signs of overheating with skilled labour and material prices, as well as the overall cost of construction rising sharply. It became clear that a major cause of this was an across-the-board push for development by the public sector. Every Ministry had major projects on the go and/or on the drawing board, and it was clear that there was need for a more rational scheduling of major public sector projects. This, however, was overtaken by events and the recession of the mid 1980s

The decline in petroleum prices in the 1980's led to a sharp contraction of the economy in terms of both output and unemployment. Between 1982 and 1989 total real GDP fell by almost 30%, and construction's share of GDP also fell dramatically from 17% in the 1981/82 period to 7.7% in 1990. While the GDP was declining, the unemployment rate was increasing sharply from 9.9% in 1982 to 22% in the late 1980's.

In the 1990s the economy recovered strongly, particularly in the closing years of the century. During this period, as shown in Table 1, the unemployment rate also declined from 22.0% in 1989 to 10.4% in 2002, however, at the same time the construction industry has consistently had unemployment figures significantly above those of the economy in general.

It can also be seen in Table 1 that construction has been responsible for more than 12% of total employment even though it has only contributed less than 10% of real GDP. This suggests that construction labour was less productive than the average across the economy. In an economically efficient market this should mean that labour would migrate from construction to where its marginal product is higher, or that construction productivity (as measured by output per capita) should increase to the industry average. Neither seems to have happened in the statistics up until 2002.

Table 1 Economic parameters for Trinidad & Tobago 1973-2002

	Real GDP Growth Rate (%)	**Real Construction as % of GDP**	**Construction as % of Total Employment**	**Unemployment Rate (%)**	**Inflation Rate (%)**
1973	1.70	6.78		15.40	14.90
1982	3.80	16.95	18.45	9.90	11.4
1983	-10.31	15.66	18.03	11.1	16.8
1984	-5.80	13.24	17.02	13.3	13.3
1985	-4.12	11.18	15.45	15.7	7.7
1986	-3.28	8.77	13.76	17.2	7.7
1987	-4.57	8.36	13.03	22.3	10.8
1988	-3.92	8.58	10.90	22	7.8
1989	-0.83	7.85	10.56	22	11.4
1990	1.50	7.74	10.73	20	11.0
1991	2.69	8.37	11.47	18.5	3.8
1992	-1.65	8.59	10.89	19.6	6.5
1993	-1.46	8.15	11.03	19.8	10.8
1994	3.57	8.83	10.16	18.4	8.8
1995	3.96	9.16	10.06	17.2	5.3
1996	3.83	9.31	10.09	16.2	3.3
1997	2.82	9.14	11.27	15	3.6
1998	7.77	9.60	12.53	14.2	5.6
1999	4.39	9.79	12.55	14.6	3.4
2000	5.80	9.50	12.70	11.6	3.5
2001	2.80	9.70	14.12	10.8	5.6
2002	4.60	9.62	13.98	10.4	3.9

Source: Own derivation from Statistics published by the Government of Trinidad & Tobago

One reason for the apparent low productivity could be that the skill level in the marginal construction worker is well below the average, so expanding construction inevitably leads to lower short-term productivity. It is also possible that the low productivity also results from its relatively high labour intensity compared with other sectors. This characteristic is exacerbated by the tendency for smaller scale construction work to increasingly be handled by the informal rather than the formal system, and for the informal sector to use more labour-intensive techniques of building [2]. Although this may be a less efficient approach, its characteristics are not all bad. As Wells and Wall [2] point out, a shift towards what they call 'artisanal' production "creates income and employment for a large number of semi-skilled and unskilled workers, with substantial multiplier effects to the wider community. Other benefits include widespread acquisition and development of technical and managerial skills and familiarisation with market processes, which may provide a basis for further industrial development with more complex technologies in the future."

As has been mentioned above, one distinctive feature of construction activity is the way demand and output fluctuate, typically considerably more than for manufacturing or the economy as a whole. This is a reflection of Keynes' multiplier and "is inherent in the demand structure of capital goods industries where relatively small changes in demand by consumers will cause the production capacity to be expanded or contracted at a considerably higher rate." [3]. The figures for Trinidad & Tobago (see Table 2) show that when the economy is growing, the construction sector tends to grow faster than the other sectors. In fact it tends to grow almost twice as fast as the growth rate for the economy as a whole. When the economy is contracting construction appears to decline at a faster rate than the other sectors and total GDP. Thus, the multiplier operates in both directions.

Table 2: Sector performances in Boom and Bust, (Average Growth Rate, %)

Periods	Total Real GDP	Construction
1951-61	8.0	15.2
1966-73	3.1	8.3
1974-82	6.1	13.4
1983-93	-2.2	-9.1
1994-2003	4.7	7.0

Source: Own derivation from Statistics published by the Government of Trinidad & Tobago

3. Perspectives on the Construction Sector

Wells [4] uses the term 'construction' to describe "the creation of physical infrastructure (roads, railways, harbors), other civil engineering works (dams, irrigation projects, power plants), all building work (including housing) as well as the maintenance and repair of existing structures." By its very nature, construction has strong backward and forward linkages with other sectors of the economy - buying its inputs from many different sectors and selling its output to all sectors. As a result, the value added or 'net' output of construction *per se* is only a small part of the total 'construction' process, especially given that a large percentage of total construction output consists of intermediate inputs from other sectors of the economy. The 'multiplier' effect of on-site construction activity has been estimated at two or two and a half times the net value of construction output [4].

The industry converts financial assets into physical assets, while directly and indirectly generating income and employment. The extent of the 'multiplier' effect in the home economy depends on how much of the required goods and services are sourced locally. Trinidad & Tobago is developed enough to be able to offer a fairly full set of inputs to construction and to benefit from most of the multiplier effects. [2]

4. Narrow and Broad Definitions of Construction

Construction can be defined narrowly as an industry focused on on-site construction activity. The broader definition includes for example, the quarrying of raw materials, the manufacture and supply of building materials and the various associated professional services (including demolition). In the UK it is estimated that the broadly defined construction sector has more than twice the numer of firms as narrowly defined industry. Furthermore, this "doubling rule tends to carry over to many of the indicators of the size of the industry" [5]. The official statistics only record the narrowly defined industry. However, the whole of the sector responds as one entity during times of expansion and contraction, so the total impact of construction is at least double that shown statistically.

Furthermore, there is an element of the formal construction sector that is not measured by the statistics as well as there being a large and active informal sector. The unmeasured formal sector involves what are called direct labour organizations (DLOs). These are organisations that provide construction services to themselves. These organisations are non-construction oriented and may be either public or private - with ministries and other agencies providing DLO construction services to the public sector, and the private sector DLOs undetaking a range of in-house construction work. DLOs are estimated to account for 6.3% of total industry output and a slightly higher proportion of industry employment in Trinidad & Tobago [6]. It is estimated that there is also self-build housing (including some housing built by contractors for private individuals) that is rarely recorded in the statistics and it has been estimated to represent about 4 to 5% of total industry output.

The informal sector is also of major importance in construction. This involves both legal and illegal elements. The former includes do-it-yourself building which is a common activity of significant importance. The latter includes what Feige [7] defines it as "those economic activities that circumvent the costs and are excluded from the benefits and rights incorporated in the laws and administrative rules covering property relationships, commercial licensing, labor contracts, torts, financial credit and social security systems". The Central Bank of Trinidad & Tobago estimated that the informal sector provided gainful employment to some 2% of the workforce [8]. This appears to be a fairly conservative estimate given the experience in other parts of the world. Elsewhere, for example, "The size of the informal economy in India is large and about 92% of the total work force is engaged in the informal economy." [9] Giles and Tedds's [10] study of the Canadian underground economy[2] concludes that it represents about 15 to 16 percent of recorded gross domestic product (GDP). Schneider's [11] measures of the average size of the shadow economy indicated that it represented around 16.7% of 'official' GDP for a group of advanced industrialised countries and 38.0% for 'transition' countries. The shadow labour force, as a proportion of the population of working age, involved in this production was around 15.3% in the industrialised countries and 30.2% in the 'transition' countries.

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[2] Incuding both legal and illegal underground activities and both cash and barter transactions.

Frey and Schneider [12] present figures derived by Schneider and Enste [13] as shown in Table 3 below, of estimates of the size of the informal (underground) economy in various countries.

Table 3: Size of the underground economy relative to 1990s GNP.

Advanced Industrialised Countries		
	Greece, Italy	27-30%
	Spain, Portugal, Belgium	20-24 %
	Sweden, Norway, Denmark	18-23%
	Ireland, France, Netherlands, Germany, Great Britain	13-16%
	Japan, United States, Austria, Switzerland	8-10%
Developing Countries		
Africa	Nigeria, Egypt	68-76%
	Tunisia, Morocco	39-45%
Central & South America	Guatemala, Mexico, Peru, Panama	40-60%
	Chile, Costa Rica, Venezuela, Brazil, Paraguay, Columbia	25-35%
Asia	Thailand	70%
	Philippines, Sri Lanka, Malaysia, South Korea	38-50%
	Hong Kong, Singapore	13%
Transition Economies		
Central Europe	Hungary, Bulgaria	24-28 %
	Poland, Rumania	16-20 %
	Slovakia, Czech Republic	7-11 %
Former Soviet Union	Georgia, Azerbaijan, Ukraine, Belarus	28-43 %
	Russia, Lithuania, Latvia, Estonia	20-27 %

Source: Compiled from Schneider and Enste [13].

Trinidad & Tobago can be considered a transition economy and so, based on Schneider's figures, it may be assumed that the informal sector employs some 30% of the workforce. If informal employment is distributed in roughly the same proportions as formal employment, then around 15%[3] of the informal sector will be employed in construction activities. This suggests that some 4.5% of the total workforce are employed informally in construction (i.e. 15% of 30%). This figure does not seem unrealistic given that there are many people who 'moonlight' by doing more than one job, and that there are a large number of small, unregistered firms that ply their trade in construction but go unrecognised officially.

Finally as an element of the informal sector is the self-help or do-it-yourself type of work, and this is a major contributor to construction output in the Caribbean. For example, it is quite common for relatives, friends and neighbours to get together to work on one another's houses. This 'do-it-yourself' and 'self-build' activity is a legitimate and large contributor to the economy and is estimated to contribute between 11 and 19% of the output of all construction activity in developed economies [14]. Because of the extent of the mutual aid and self-help approaches to constructing, renovating and extending housing in Trinidad & Tobago it is suggested that this 'do-it-yourself and self-build' activity would represent the top end of the

[3] This is roughly mid-way in the range 10%-20% typical for T&T over the past 30 years.

range and hence contribute around 19% of the output of formal construction activity, and the same proportion of employment.

This would suggest that the reported employment figures for construction, are significant underestimates of the true extent of employment in the sector. It is not clear whether the informal sector will react to changes in the economy in the same way as the formal sector[4]. It is possible that as the formal sector expands the informal sector would contract, as there would be less need for informal employment. However, anecdotal evidence and personal experience suggest that this is not the case, and that as the economy expands workers are no less likely to have second jobs, and that the covert construction economy expands at least as much as the overt construction economy during boom periods. The implication, of course, is that policy measures taken to expand construction would have an even more significant impact on employment (and the economic multiplier) than indicated by the official statistics.

Table 4: Summary of the employment effects of broadening the definition of construction

Employment in narrowly defined industry	Add 100%[2] for jobs in the broadly defined sector	Add 4.5%[1] for informal sector	Add 6.3%[1] for DLOs	Add 19%[2] for self-help and d-i-y	Total Employment

[1]Percentage of total employment [2]Percentage of industry employment

Given the tendency for larger and larger trading blocs to be established internationally, it is necessary to briefly look at how the requirement for such economies to be open will affect the construction sector. Of most importance may be the fear that many countries have that the 'freedom of movement of people' guaranteed within these blocs will lead to floods of people moving from the poorer areas to those that are better off. History shows that major development or redevelopment efforts have largely been accomplished by construction labour that has migrated from the poorer countries to the richer countries. As Drewer [1] notes "historically every major infrastructural development programme has required a dramatic migration of workers to satisfy the insatiable demand for construction labour" and that "during the early 1980s there were more than 150 thousand Korean construction workers in the Middle Eastern oil exporting countries working for Korean contractors".

5. Conclusions

The non-measured elements of the construction sector are of major importance. The figures suggest that the reported employment statistics for the construction industry, are significant

[4] Various factors have been shown to affect the scale of employment in the informal sector the most important probably being the burden of taxation (size and complexity) that the individual faces in a society [15][16], and the burden of regulation as indicated by the strength and efficiency of government [17]. Schneider and Enste [18] provide a good overview

underestimates of the true extent of employment in the sector. Table 4 summarises the effects of the various elements discussed here.

The figures suggest that if the *industry* employment represents 100%, the additional services that make up the *sector* add another 100%, mutual aid and D-I-Y add a further 19% of industry employment, while direct labour accounts for an extra 6.3% of the total employment, and the informal sector adds another 4.5% of total employment. Thus it may be reasonable to assume that the construction sector actually provides employment for around 300% of the figures quoted in the official statistics for the construction industry.

By way of future research it would also be important to empirically assess the performance of both the formal and informal aspects of the construction sector, and this is the subject of a future study by the authors in the near future.

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Capturing and Utilising Knowledge for Effective Employee Resourcing within Large Construction Organizations

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Abstract

The employee resourcing component of strategic human resource management (SHRM) comprises staffing, performance management and human resource administration functions. In order for it to be managed effectively, it requires the systematic and concurrent combination of dynamic organizational, project and employee data in order that appropriate resource allocation decisions can be made. Whilst much of the knowledge necessary for effective resourcing is categorical (or explicit), some employee-centred data (such as that relating to an individual's background, personality, skills and personal preference) is tacit in nature and thus is difficult to elicit and use in decision making. This research investigates ways in which large construction organizations can overcome these challenges in a way which takes account of employees' needs. It explores how such knowledge is currently captured within leading construction companies operating within the UK and, based on a synthesis of this practice, develops a framework for enabling other firms to elicit the tacit knowledge required for robust resourcing in the future. Effectively implemented, the framework has the potential to enable construction companies to take account of individual employee needs in the future. However, its successful operation will demand a culture of trust and openness if employees are to be explicit in stating their aspirations, abilities and limitations, all of which are vital for effective resourcing decision making.

Keywords: Resourcing, employee centred knowledge, decision making employment relationship.

1. Introduction

Employee resourcing is one of the key strategic human resource management (SHRM) functions within construction organizations [1, 2, 3, 4: p83]. It embodies core SHRM activities such as the recruitment, selection and deployment of employees within the organization, which should be managed in such a way as to support the strategic objectives of the firm. However, despite the vital importance of effective team selection and formation to the success of organizational performance, employee resourcing remains a reactive and largely operations-focused function in most construction firms. This reflects the fact that most construction companies remain grounded in the traditional "personnel management" style people management practices, rather than those associated with the strategic human resource management (SHRM) approach [5, 6]. Under personnel management, a focus is placed on staffing administration and compliance with legislative and regulatory conditions (ibid.). In contrast, the concept of SHRM is that the effectiveness of an organization largely depends on the efficient use of its human resources which is achieved through employee commitment, flexibility and quality of work [7: p503]. Thus, as with many other aspects of management practice, HRM is currently underdeveloped within the sector [4].

A possible reason for the underdevelopment of the HRM function within construction is that allocating staff to projects demands the concurrent balancing of the often competing requirements of the organization, the project and individual employees. Whereas project and organizational resourcing requirements are relatively easy to discern, capturing employee needs and integrating them into the decision process is more problematic. This is because the knowledge requirements necessary are mainly tacit in nature, as they relates to an individual's aspirations and personal preferences, as well as their professional experience, skills and competency. Being highly personal, such tacit knowledge is very difficult to communicate or share with others [see 8, 9]. If it is managed poorly or excluded from the decision making process with regards to human resource allocation and development, the result is likely to be dissatisfied employees and higher levels of staff turnover. This, in turn, is likely to disrupt projects and the achievement of strategic objectives. Thus, incorporating individual employee needs into the resourcing decision making process represents a major knowledge management challenge for construction firms.

Despite the recognised importance of the resourcing function and its wide reaching impact on construction people management, relatively little research has been undertaken in the area. This paper reports on a project which set out to develop a more robust methodology for capturing employee requirements of the resourcing process and integrating them into the resourcing decision making process. It examines the resourcing practices of leading UK based contracting organizations, focusing on how the tacit knowledge held by employees is fed into the resourcing decision making process. By combining effective elements of this practice and supplementing this with leading edge SHRM thinking around the resourcing function, it provides a framework for incorporating such decisions into the resourcing process in the future. This offers a new paradigm for incorporating employee needs within decisions which have hitherto been oriented towards the achievement of project goals at the expense of individual requirements of the resourcing process.

2. The Challenge of Effective Employee Resourcing in Construction

The employee resourcing function aims to match human resources to the strategic and operational needs of the organization, thereby ensuring the full and appropriate utilisation of those resources [10]. Whereas in most industries this represents the coordination of a set of fairly controllable tasks, the nomadic, transitory and project-based nature of construction often results in employee needs being ignored. This is primarily because construction projects tend to have a short lead-in time which demands the rapid mobilisation of teams [4: 84]. This is despite of the fact that construction organizations usually manage these activities centrally within specialist departments or within divisional/ regional senior management teams [ibid: 83]. As is stated above, this reactive practice clearly overlooks the strategic importance of the development of highly committed employees who participate in the development of the organization.

The major components of employee resourcing comprise: staffing, performance, HR administration and change management [11]. These functions comprise several discreet but interrelated management activities, as summarised in Table 1. The *staffing* and *performance* objectives aim to ensure that the right numbers of employees with the right skills and competencies are in the right place at the right time. This is a balancing act in which managers are tasked with taking into account the longer-term strategic considerations of human resource planning (HRP) while providing immediate solutions for the shorter-term operational issues, such as recruitment and selection, team deployment, dismissal and redundancy [12, 13]. Ideally, management of staffing and performance are simultaneously concerned with ensuring the best possible performance is achieved whilst facilitating employees' career progression and offering them appropriate reward for their efforts. *HR administration* focuses on the collection, storage and use of employee data supporting the monitoring and analysis of HR information (14: p22). The *change* aspect of the function aims to achieve appropriate recognition for the significance of change and facilitate the continuous evolution of the organizational strategies and practices through the interrelated aspects of staffing, performance and HR administration.

Table 1: Employee resourcing tasks with related SHRM activities and objectives

SHRM objective	***SHRM activity***	***Tasks involved***
Staffing	Human resource planning (HRP)	Strategic human resource forecast (SHRF) – an input; development of a human resource plan – an output
	Recruitment and selection	Identification and analysis of recruitment needs; drawing of job descriptions and person specifications; advertisement of the vacancy; shortlisting candidates; selection process utilising appropriate selection techniques (i.e. interviewing, assessment centres, etc.); selection of the 'right' candidate; induction
	Team deployment	Formation and building of effective teams; deconstruction and redeployment of teams
	Exit	Redundancy, retirement, dismissal, voluntary exit
Performance	Performance management	Continuous evaluation and performance appraisal; feedback and reward
	Career management	Promotion; personal and professional development planning (PDP)
HR admin.	Collection, storage and use of employee data	Utilisation of appropriate HR administration system, e.g. manual filing system or a computerised human resource information system (HRIS)
Change management	"Change agent"	Ensuring proper recognition is given to significance of change; management of business and SHRM processes via which organizational culture and structure continually evolve

It can be appreciated that managing all of these functions concurrently represents a complex and challenging task for any large organization. However, within construction companies, additional external factors have an impact which renders it even more problematic. In particular, the challenging physical environment of the construction industry is a particularly problematic context for effective employee resourcing.

Unsurprisingly, current employee resourcing practices usually rely on the personal assessments of line managers [15]. These have the potential for inconsistencies, personalised allocation decisions and hence, disillusioned employees through the violation of a 'psychological contract' [1]. The domination of project and organizational needs predominating the resourcing process, has the potential to contribute to increase employee turnover and hence to contribute to the overall inefficiency of the industry. This places extreme demands on both HR departments and line managers, and requires a flexible approach to the employee resourcing function in construction organizations [1]. This requires the different components of the employee resourcing function (i.e. staffing, performance management, human resource administration and change management) to be integrated to form an interconnected network of decision-making and support processes [11]. Modern human resource information systems (HRISs) offer facilities to assist in this task [see 16, 17, 18]. However, these only provide data management tools and therefore must be supported with carefully conceived and well-managed strategies to support the organization's business objectives.

3. Tacit Knowledge and the Resourcing Process

As is explained above, recognition of employees' individual requirements of the resourcing process is fundamental to their effective management . This is a considerable challenge in terms of capturing knowledge about employees' individual preferences and using it for resourcing decisions . This is because the majority of necessary knowledge will be tacit in nature and therefore not easily visible or expressible. However, although such knowledge is highly personal and therefore difficult to communicate or share with others [8, 9], it is essential that it is captured if employee needs and aspirations are to be taken into account.

In recent years, there has been a great deal of interest in developing ways to manage knowledge more effectively in construction organizations, primarily through the development of new information and communications technologies (ICT). However, this emphasis has largely been at the expense of efforts to explore the human dimensions of effective knowledge management [19, 20]. Arguably, an overemphasis on technological solutions for managing knowledge within large organizations has contributed to the relatively high failure rate of knowledge management (KM) within many industries and organizations [21, 22]. Thus, there is a practical need to integrate KM programmes with human resource management (HRM) policy, to ensure its effective contribution to the performance of the modern business [20, 22].

Much of the current work in the area of knowledge has emerged from the initial work of philosopher Michael Polanyi. Polanyi first made the distinction between tacit and explicit knowledge [23, 24]. He describes these as two different types of knowledge rather than two forms of the same thing. Tacit knowledge is known, but difficult to say (i.e. locked in the mind). Conversely, explicit knowledge can be expressed in words or numbers and shared in the form of data, scientific formulae, specifications and manuals [25]. This kind of knowledge is readily transferable within the business community, and can be codified and stored in databases where it can be accessed and used easily. However, explicit knowledge may represent only the metaphorical 'tip of the knowledge iceberg' of the resourcing function.

Nonaka expands the concept of tacit knowledge and states that tacit knowledge includes cognitive and technical elements [see 26, 27]. The cognitive element centres on mental models in which humans form working models of the world by creating and manipulating analogies in their minds. These include schemas, beliefs, and viewpoints, which help individuals to perceive and define their world. The technical element of tacit knowledge includes specific know-how, crafts, and skills. For example, a manager may develop a wealth of expertise after years of experience but s/he is often unable to articulate the technical and philosophical principles behind it. In contrast to Polanyi, Nonaka also sees a connection between tacit and explicit knowledge in that they interchange into each other in the creative activities of human beings. This perspective is highly relevant to the resourcing process, where decisions about an individual's suitability for a project will be determined by both their skills and knowledge of relevance to the endeavour, but also their personal aspiration and desire to involved within it. These types of knowledge come together in the process of deciding upon whom to allocate to project teams.

A key factor in ensuring that this is managed effectively is developing a climate of trust in the employment relationship between employers and their managers. Trust is important because employees will not be willing to share their work-related knowledge unless that feel secure that it will be used for them rather than against them [28].I If employees feel that their employment relationship is not fair, if they feel that work-related promises or commitments have not been kept, and if they do not trust their employer to keep promises or commitments in the future, then they are less likely to feel disposed to share knowledge at work. Ellis [29] argues that it is difficult to manage knowledge without trust, as most people will not risk sharing what they know without it. However, this can be seen as problematic within the context of the knowledge required for managing the resourcing process, the success of which effectively depends upon identifying: (i) the skills and experience that an employee brings to their role; (ii) their limitations in relation to the tasks inherent in the project for which they are being considered; (iii) learning opportunities in terms of further developing the individual's skills, competencies and abilities; and (iv) employees' personal needs and career aspirations reconciled against the project opportunities on offer. Clearly, identifying and understanding the limitations of employees is problematic given that most employees will not wish their weaknesses to be known by their employer. Even their positive knowledge and competencies may be seen as a commodity which they may be reluctant to convey to their employer in fear of them strengths being exploited in areas of the organization where they do not wish to work. However, the most difficult tacit knowledge to identify is the personal needs and aspirations of individual employees. Thus, finding ways for employees to feed this data into the decision making process is fundamental to the successful management of the resourcing process. If managed successfully, appropriate opportunities for employees to develop within the organization can then be identified.

4. Research Methodology

As is discussed above, this paper reports on a study which investigated the ways in which large construction firms attempt to elicit employees' tacit knowledge of relevance to the resourcing process. Much of the previous research on construction employee resourcing has focused on examining particular aspects of the function, such as recruitment and selection [30], project allocation [31, 32] or team building [33], adopting largely quantitative methodologies and developing solutions that primarily seek to satisfy the organizational/ project requirements and objectives. These approaches have ignored the benefits that a tailored strategic approach and qualitative methodologies can offer and so an interpretative qualitative framework was used. However, two challenges had to be overcome. Firstly, gaining an understanding of the complexities of the resourcing process and the approaches used to manage the function is problematic given the environment within which construction contractors operate [29]. Secondly, the researchers had no *a priori* knowledge of the likely approaches adopted by construction companies from which a hypothesis could be derived. Therefore, an inductive methodology was chosen which allowed for the examination of the resourcing process from a variety of stakeholder perspectives with the aim of gaining a holistic view as to how the function is managed. The methodology also made the collection of in-depth case study material possible, which allowed employee resourcing activities to be investigated from several perspectives for single project examples.

Table 2 profiles the organizations that agreed to participate in the research. They were chosen as they operated throughout the UK and their activities spanned every major sector of construction activity. All of the companies were in the leading twenty UK contractors measured by annual turnover. Each provided a range of staff who were interviewed in a semi-structured manner. The informants comprised senior HRM staff, directors, senior operational managers with responsibility for resourcing decision-making and a selection of project-based employees at various levels of the organization. A research instrument was developed to guide the discussions to cover all the major topics within employee resourcing and HRM these also incorporating issues specific to project-based sectors. The interviews were recorded, transcribed verbatim and then coded and analysed using NVivo™ qualitative analysis software. NVivo proved invaluable in aiding the codification and organization of the research material and also in allowing for exploratory searches to be carried out on keywords, nodes and/ or attributes [see 34].

Table 2: Participating organizations

	Case study	***Sector***	***Turnover (UK£'000s)***
A	National contractor	Building	1,074.000
B	National contractor	Civil engineering	487.238
C	National contractor	Civil engineering	1,680.000
D	National contractor	Building	1,382.200
E	National contractor	Civil engineering	1,335.900
F	European contractor, UK division	Building	706.000

5. Findings

It soon emerged that no single organization managed the resourcing process effectively as a whole. However, several areas of good practice emerged in terms of ascertaining employee needs from the resourcing process and including these within decision making practices. The aspects of the case study material useful for the development of a Strategic Employee Resourcing Framework (SERF) are outlined below.

5.1 Human Resource Planning (HRP)

The HRP aspects of the resourcing function revealed some innovative practices amongst the participating firms. One such approach (Company D) focused on *succession planning*. This involved the identification of people who showed director-level potential, who were subsequently placed on executive development programmes. In company B, HRM specialists and departmental directors collaborated in identifying suitable candidates for their intensive management development programme. Their selection criteria were drawn from business plans and current organizational capability charts. A named member of the HR team had the overall responsibility for overseeing and facilitating the process providing a single contact point for all involved. This ensured effective integration of the organizational strategic and operational requirements of the business with a management team capable of providing the services and products that clients demand. Many organizations also placed great importance on *graduate development*. Showing long-term commitment to developing graduates and offering them transparent progression opportunities were seen as key factors to successfully retaining the brightest candidates. Companies A and D in particular specialised in student and graduate development as a long-term staffing strategy. This type of long-term approach to graduate recruitment illustrates an effective integration of the strategic HRP and recruitment and selection activities integrated with HRD. The key to both the successful succession planning activities and the graduate was the transparent identification of those with potential in the organization. Rather than base promotions and accelerated career development on informal assessments of staff ability, the most successful firms had an open system whereby the criteria underpinning the selection of people for such schemes were explicit. This enabled those outside such schemes to target improvements to relevant skills and competencies.

5.2 Recruitment and selection

The compatibility of a company's value system to that of the potential candidate's was said to be one of the main determinants of resourcing success. Thus, company A actively promoted the company culture within their recruitment process and adverts in a bid to ensure that applicants' attitudes and abilities aligned with their desired values. In articulating the company values and culture in this way, this company had tried to ensure that potential employees were clear as to the behaviours that would be expected of them if they were appointed. They had put considerable effort into converting the implicit assumptions and working practices into a tangible description of their operating culture.

5.3 Team deployment

Company D operated a particularly effective approach to the team deployment process which exemplified the need for tacit knowledge capture from within the resourcing process. Four main sources of information were drawn together to form a comprehensive picture of a potential team member's suitability for a project:

- Technical competence assessments (from job descriptions, experience summary sheets and chartered status records)
- Personal development assessments (to support technical competence evaluation and provide information on personal aspirations, needs and preferences)
- Personal relationship records (line managers' knowledge on how the employee works with other people and works as part of a team)
- Availability and personal requirements (employee availability, current project/ commitments, potential disturbance of a move mid-project and employee personal requirements).

By systematically considering these four sets of criteria, robust assessments could be made of the most compatible project for each individual employee. Similarly, teams could be selectively and gradually dismantled in such a way as to avoid disrupting project management by aligning particular skills with particular project stages. This also facilitated the effective redistribution of knowledge from the project and its team members' experience of other sites. Regional engineering managers had been introduced to form a formal communication link between the site and office based staff. Their role had also been proven effective as an alternative for direct line management contact regarding appraisal interviews, career management discussions and grievance procedures. In effect, their role had been to manage the capture of knowledge relating to employees' abilities and needs from the resourcing process.

5.4 Performance management

Performance management was found to be the principal tool used for capturing the data necessary to underpin resourcing decisions. Company C and Company F used a similar performance management system which had a post-project appraisal feature, which meant that employees had an appraisal meeting after each project in addition to their annual performance review. This comprised an open discussion on the employees' performance on the project , what he/she had learned and what they would like to do next. This provided information that could be used in personal development planning. The developmental aspects of the project appraisal discussion had helped employees and their managers to monitor their progress and the achievement of the targets set in the performance appraisal. Moving towards a project-related appraisal process was seen as crucial for the effective management of the resourcing function, particularly because it was easier to articulate learning experiences immediately following project completion than on an annual basis as is typical in most organizations.

5.5 HR administration

Developing a repository and retrieval mechanism for managing the employee data necessary for effective resourcing was seen as crucial. Although none of the participating firms had developed such technology, Companies A and E were in the process of building internal HRP information systems. These were envisaged to include facilities for comprehensive data management and decision-support. In company E the system was to replace the current divisional databases and provide a centralised information source for the group as a whole. It was to run separately from the group's personnel database, but with capabilities for data sharing between the two. This ICT capability was seen as crucial for facilitating the rapid entry and retrieval of employee records for facilitating resourcing decisions.

6. Discussion: A Framework for Capturing and Integrating Employee-Derived Data within the Resourcing Process

The analysis of the good practice elements from the six case study organizations revealed that none of the firms provided a wholly robust methodology for capturing knowledge on employees' individual abilities, needs and aspirations as part of the resourcing process. However, by taking elements of each of the practices used by the firms, this provides a framework which could address the challenges posed by project resourcing within the construction industry. This framework (Table 3) forms the underlying process elements of a Strategic Employee Resourcing Framework (SERF) [see 35 for a full description of the SERF model]. In addition to the process element, the framework consists of a web-enabled user interface and a Human Resource Information System (HRIS) application. The SERF connects the resourcing functions (HRP, recruitment and selection, team deployment, performance management and HR administration), thereby enabling them to be integrated with the wider HRD and employee involvement elements of SHRM. Such an integrated tool presents a radically different resourcing paradigm in comparison to the industry's traditionally production-oriented approaches as it integrates the organizational, project *and* individual employee needs into the process.

Table 3: Framework for Capturing and Integrating Employee-Derived Data within the Resourcing Process

Core resourcing element	**Challenges of managing process within a construction context**	**Good practice identified from case study firms related to tacit knowledge capture**	**Benefits for the successful management of the resourcing process**
HRP	Nomadic, transitory, project-based sector	Transparent identification of succession criteria	Effective integration of strategic and operational business requirements Long-term staffing strategy integrated with HRD
Recruitment and selection	Fluid and dynamic environment	Organizational culture explicitly described throughout the recruitment process	Efforts targeted at suitable population Candidates' value system matches that of the organization
Team deployment	Need to balance external, organizational, project and employee variables	Multiple sources of decision-support information Facilitation of communication from projects to office-based managers	Flexibility Quality of work High staff morale Effective knowledge transfer
Performance management	Reliance on personal assessments of line managers	Post-project reviews Structured performance management systems	Employee commitment Team deployment decision-making support Tool for employee voice and two way discussion
HR administration	'Personnel' (Rather than SHRM): low take-up on technology	HRP information system/ HRIS	Comprehensive data capture and sharing Decision-support for resourcing decisions

6.1 Case study

In order to examine the practical application of the framework described above, it was tested in a programme comprising the construction of ten schools divided into four projects. Each project had a Project Manager, responsible to the Contracts Manager, who assumed responsibility for the production teams for one, two, three or four sub-projects. Each sub-project had a site manager who was responsible for the supervisory staff (foremen, engineers, trainees) and directly employed labour. On one section of the overall programme the staff were all new to the organization, apart from a site manager based on sub-project two. He was one of the longest serving members of the organization with 35 years experience in the region. The others had been specifically recruited for the projects . Other projects within the programme had high proportions of existing personnel supplemented with a few freelance and/ or newly recruited staff. One section four had a balanced mix.

This initial staffing strategy adopted by the case study organization resulted in multiple challenges throughout the overall programme duration. The new Contracts Manager required extensive resourcing guidance from his longer serving colleagues. The organization had no written policy or procedures for team deployment. Similarly, in recruiting new personnel he had to actively seek advice so as to be able to follow established unwritten company practice. At the site level, there was extreme pressure to meet expected performance levels. New recruits were trusted to undertake the work with the guidance of an older, very long serving site agent. Although this allowed for fresh ideas and working methods to be brought into the project, this was at the price of unproven working relationships and hence, reduced team synergy. The problems faced by the staff had been compounded by an abject lack of written policy or procedures on recruitment and selection or team deployment.

The resourcing framework was used in subsequent projects within the programme to address many of the issues emerging from its early operation. Firstly, in terms of policy and procedures, the system provided full details of all organizational and good practice guides on employee resourcing, HRD and other elements of SHRM. This included recruitment and selection procedures and team deployment processes, which ensured the effective utilisation of staff across the organization, its sub-divisions and departments as well as individual programmes as in this case. Thus, the inequalities between sections one, two, three and four were highlighted in subsequent project planning stages and new and experienced personnel were allocated to the projects more evenly. Secondly, the HRD element of the framework ensured that individual employees' or organizational tacit knowledge was transferred to the project through the appropriate use of company personnel. This alleviated the team building difficulties experienced and also develop useful future relations within new members of staff within the organization. This tacit knowledge was used to enhance internal relationships and thus, to foster organizational commitment.

The HR administration element of the framework, the HRIS, supported timely and accurate employee data storage and retrieval. This included explicit information about their background and skills, but also tacit information which refers to their experience and expertise. This data bank was used as a directory of organizational expertise through which resources could be deployed according to organizational and project requirements. At the same time, the employee involvement aspect of helped to ensure that the individual employee needs and preferences in terms of work-life balance, career ambitions, etc. were incorporated into the managerial decision-making. This way transparent and balanced decision-making took place, which was used to rapidly satisfy employee/ client enquiries. In the long-term such a system can help in planning employee progression and also encourage repeat-business.

7. Conclusions

This paper has explored how knowledge is currently elicited within leading UK construction companies. Based on a synthesis of this practice, a framework for enabling other firms to capture the tacit knowledge required for robust resourcing in the future has been developed. Capturing individual employee perspectives on their skills, competencies and personal needs is the cornerstone of any successful project resourcing strategy. Such knowledge is difficult to take into account as it is tacit and specific to every individual employed by the organization. Nevertheless, if an organization fails to take employee needs in the resourcing process, the implications are likely to be detrimental both to project performance and to staff development and retention. Thus, capturing employee's perspectives on the resourcing process is key to the efficacy of the HRM function within large construction businesses. Although none of the firms participating in this research had developed a solution which demonstrably resolved the resourcing challenge, a synthesis of the best practices of those identified has resulted in a more robust methodology for addressing the challenge of taking into account employee perspectives in the resourcing process. However, its successful operation will demand a culture of trust and openness if employees are to be explicit in stating their aspirations, abilities and limitations. Although this may present a significant challenge to construction organizations, if both parties work to develop such a culture then the benefits should be employees who are appropriately deployed in a way which is sympathetic to both their needs *and* those of the organization.

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Modelling Construction Skills Supply for the Zambian Economy

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Abstract

The development of requisite skills in the right numbers to match the sector demands in construction within Zambia forms an essential aspect of the ability of construction companies to deliver projects efficiently. The availability of these skills is influenced by a number of factors including the training provision which governs the supply of the skills, sector and sub-sector volume capacity which drives the demand for the skills, and other socio-cultural as well as public sector policy on skills development. The nature of the interaction between the two principal factors of demand and supply for a developing country such as Zambia is particularly relevant as these two factors are self-reinforcing and also impact on the other socio-politico cultural factors. The paper explores the interaction the two factors by examining the supply pattern of selected construction skills and how they reflect current skills needs (demand) of construction companies in Zambia. The scope of the analysis is craft-based and technician grade skills. The benefits of the analysis derives not only from the potential to identify possible skills shortfalls to inform public policy, but also highlight any change in the composition of the skills base that the supply organisations (construction sector training providers) may have to address.

Keywords: construction, skills, training, policy, demand, supply, Zambia.

1. Introduction

The construction industry in Zambia, as in many developing economies, is dominated by labour-intensive methods of production (Muya et al., 2003; Edum-Fotwe, 2003). This orientation for the production activity within construction means that the availability of requisite skills to the industry impact heavily on its capacity to deliver demanded outputs. The development of requisite skills in the right numbers to match the sector demands in construction within Zambia forms an essential aspect of the ability of construction companies to deliver projects efficiently (GRZ, 1996). The availability of these skills is influenced by a number of factors including the training provision which governs the supply of the skills, sector and sub-sector volume capacity which drives the demand for the skills, and other socio-cultural as well as public sector policy on skills development (World Bank, 2003). The nature of the interaction between the two principal factors of demand and supply for a developing country such as Zambia is particularly relevant as these two factors are self-reinforcing and also impact on the other socio-politico cultural factors. The research forms part of a much larger study funded by the DFID and administered by the British Council in Zambia. The objectives of the main study are to undertake the following activities in Zambia:

- examine current government policy and expenditure with reference to training and retraining of the workforce in the construction industry;
- investigate trends in outputs of institutions involved in training and retraining of the construction industry workforce;
- audit construction industry skills deficit through a survey of construction industry employers;
- explore levels of private sector participation in training and retraining programmes;
- identify constraints to implementation of appropriate training programmes; and
- assess current levels of skills possessed by construction craft workers

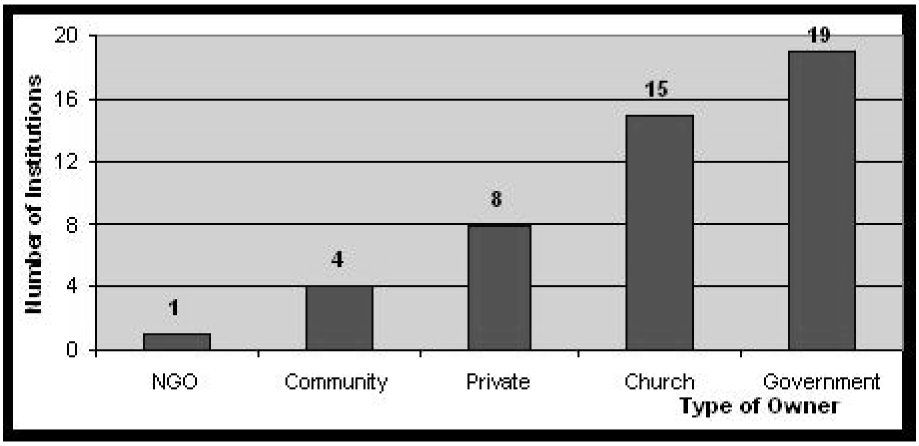
This paper explores the interaction the two factors by examining the supply pattern of selected construction skills and how they reflect current skills needs (demand) of construction companies in Zambia. The analysis is focused at the craft-based and technician grade skill levels as this presents a critical area for strengthening construction in most developing economies. The benefits of the analysis derives not only from the potential to identify possible skills shortfalls to inform public policy, but also highlight any change in the composition of the skills base that the supply organisations (construction sector training providers) may have to address.

2. Construction skills in Zambia

The development of construction skills in Zambia occurs both through formal and informal routes. The former is achieved through training and education with appropriate accreditation structures established. The latter involves hands-on apprenticeship often without any formal evaluation of proficiency. At present, the country's construction training institutions are in dire need of investment after accumulated years of under-funding and brain-drain. The continued reliance on central government to finance education and training in the country has led to the fall in standards, and the mass exodus of teaching staff due to poor conditions of service. Although the government has introduced user fees through the Technical Educational, Vocational and Entrepreneurship Training Authority (TEVETA), in almost all its institutions, the portion paid by government through budget grants remains unsatisfactory. Mashamba (2002) discuss the efforts of the Zambian government to address the current funding situation through a levy scheme.

With the liberalisation of the economy, a number of private training institutes have emerged to fill the vacuum created by the need to acquire skills in the construction industry. The Thorn-Park Construction School and the Nzelu Institute are two such private sector led construction institutions in the country. There are a number of other private schools run by individuals, NGOs, Community Based Organisations (CBOs) and churches in the country. While it may be said that Zambia is now a private sector-led economy, the government, by and large, still funds construction training at government funded institutions (Mashamba, 2002).

Since 1991, there has been a proliferation of a number of training institutions in various construction related trades. Table 1 shows that of the 47 institutes offering construction courses, only 19 representing 40 per cent are government owned. Therefore, about 60 per cent of the trade schools are either in the hands of churches, the private sector or CBOs. Outside government, churches are the main provider of construction skills training, especially in rural and peri-urban areas. Although the private sector may provide an avenue for earning a qualification and living in the construction industry, there is need to monitor the sector to avoid poor quality training.



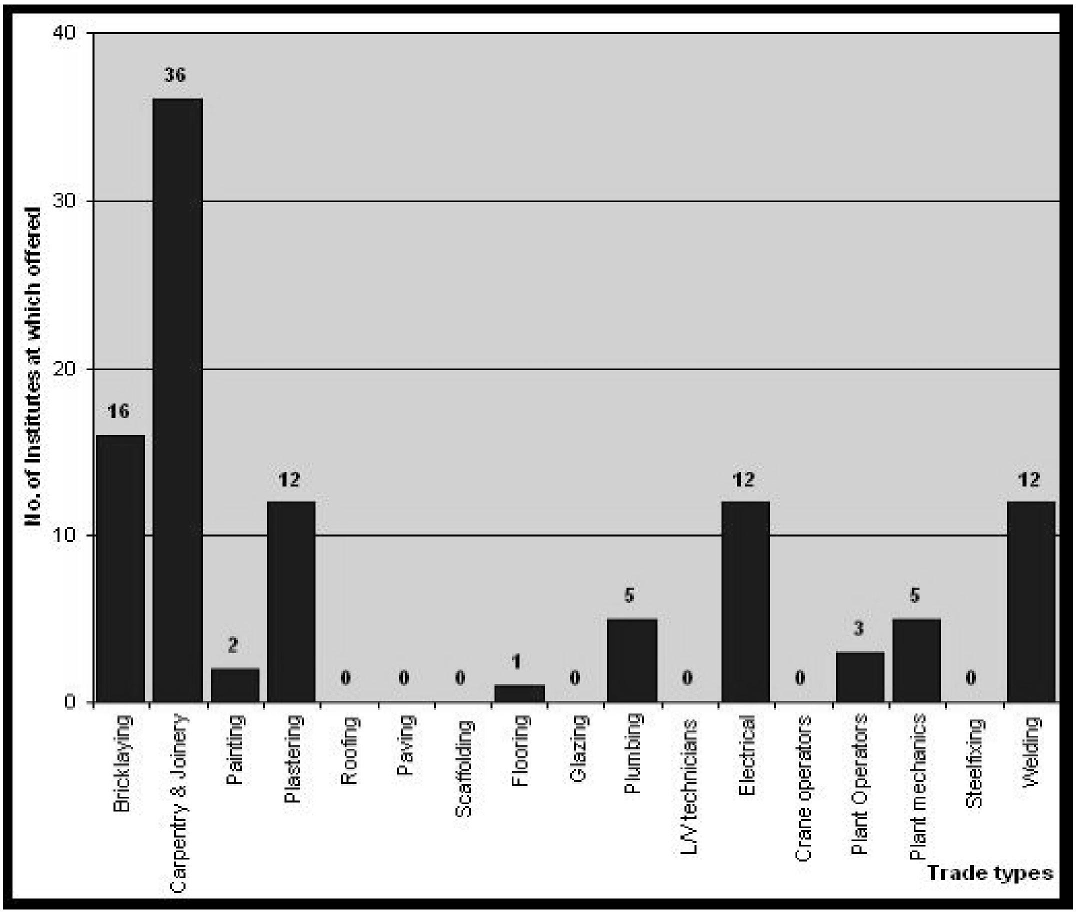
(Source: Technical Education, Vocational and Entrepreneurship Training Authority - TEVETA 2003)

Figure 1: Ownership of construction trade schools

3. Skills modelling

Agapiou et al (1995) identified the craft skills required by the construction industry to include: bricklayers, carpenters, painters, plasterers, roofers, pavers, scaffolders, floorers, glaziers, plumbers, light/ventilation technicians, electricians, crane operators, plant operators, plant mechanics and steel-fixers. Figure 2 shows the construction related trades being offered at craft schools in Zambia. While the majority of the trade schools offer courses in bricklaying, carpentry and joinery, plastering, electrical and welding, there are no programmes for roofing, paving, scaffolding, glazing, light/ventilation technicians, crane operators and steel-fixers in any of the trade schools.

There is evidence in every city and town in Zambia of high-rise buildings and other types of concrete structures that would have used scaffolding and steel-fixing expertise in their construction. It is also evident that there is wide usage of construction plant such as tower and mobile cranes in many construction operations countrywide. There is anecdotal evidence to support a view that steel-fixers and other such specialist skills acquire their training on the job in a rather informal and unconscious apprenticeship. Without training programmes in roofing, paving, scaffolding, glazing and crane operations, it may also be argued that craft-persons with skills in these areas may also have acquired their trades on the job in a similar informal and unconscious manner. This foretells an industry in limbo. No construction industry that stands to be competitive in the era of globalisation can depend on a workforce that has no formal training in key skills such as crane operations, scaffolding and steel-fixing. Other than being inefficient and uncompetitive, the health and safety practices in such an industry raise many questions. To be able to plan and make such a provision, it is essential to have a clear appreciation of the current capacity both from a demand and supply perspective. Such evidence can then help to qualify the nature and extent of skills constraints within the industry, and form the basis for any future industry strategy on improvement and development.



(Source: Technical Education, Vocational and Entrepreneurship Training Authority - TEVETA 2003)

Figure 2: Construction craft skills training offered at trade schools

4. Method of Investigation

The principal method adopted for explicating the nature of the demand and supply relationship of construction skills in Zambia is a time series approach. There are two main goals of such a time series analysis. First, it is aimed at identifying the nature of the phenomenon represented by the sequence of observations on skills provisions and availability. Second, the method of time series provides a means for forecasting for predicting future values of the demand and supply of skills variables. Both of these goals require that the pattern of observed time series data is identified and more or less formally described. Once the pattern is established, they can be interpreted and integrated with other strategic data for planning the construction industry as a whole. In this paper, the authors address the first aspect of the investigation to by providing a profile of the demand and supply of the construction skills. The predictive aspect of the investigation forms the subject of a different academic output. The provision of trained places represented by the numbers offered for final examinations is adopted as proxy for the demand of skills, and the graduation of skills as proxy for the supply of skills.

4.1 Nature and source of data

The nature of time series values are the realisations of random variables observed from real life phenomena or observations and reflect the following series detailed in equation [1]. y_t is the observed or returned value at any time t.

$$y_1, y_2, y_3, \ldots\ldots\ldots \quad \ldots\ldots\ldots \quad \ldots y_t \qquad [1]$$

These random values can be represented as a part of the larger stochastic process depicted by equation [2].

$$\{y_t : t \in \mathrm{Z}\} \qquad [2]$$

Equation [2] defines the set of all possible returns or observations of the series under investigation, in this case the demand and supply of construction skills in Zambia. It is this underlying process that will be the focus for subsequent theoretical modelling and development.

The data set was generated by reference to aggregate statistics compiled by the Examinations board responsible for technical training and education in Zambia. Current data on skills capture six principal categories. These comprise: Plumbing and Sheet-metal; Carpentry and Joinery; Bricklaying and Plastering; Painting, Decorating and Sign-writing; and Electrical. Figure 3 presents the aggregate demand and supply of the six skills in Zambia over the period 1987-2001. This illustrates the disparity between the demand and supply of skills for the construction industry in Zambia.

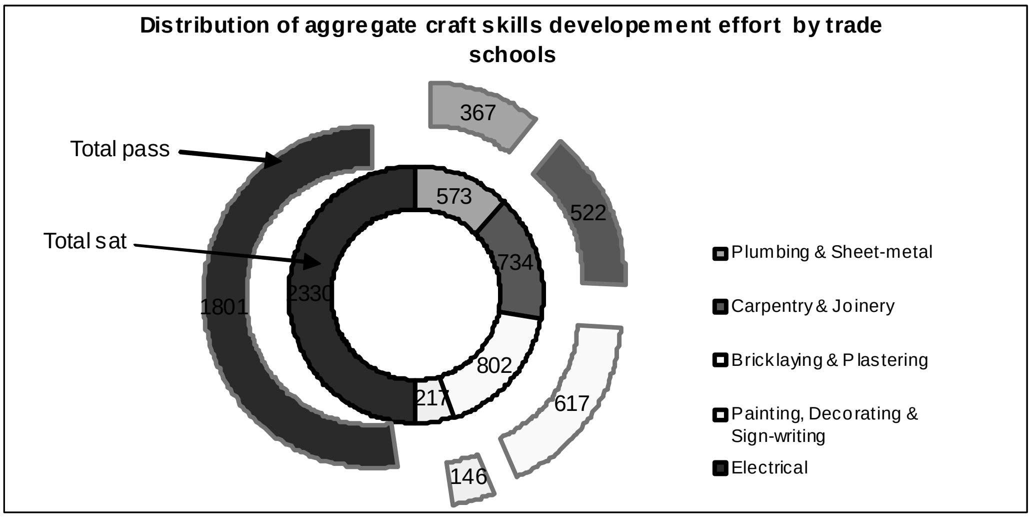


Figure 3. Number of craft skilled graduates in the construction industry: 1987-2001 (ECZ, 5-11-02

5. Analysis and Results

Figures 3, 4 and 5 present the plots of the time series for the demand for trained skills, supply of trained skills, and the ratio of supply to demand in respective order. The demand supply ratio provides an indication of the skills capacity deficit that exists within the construction industry.

The analysis presented in this paper addresses the capacity for skills supply to the construction industry. This is represented as a skills capacity index. Skills capacity index is defined by the ratio of skill of the skills supply to the skills demand as outlined in equation [3].

$$\boldsymbol{SCI_t} = \left(\frac{\boldsymbol{SS_t}}{\boldsymbol{SD_t}} \right) \qquad [3]$$

where for any period defined by $\boldsymbol{t}$:

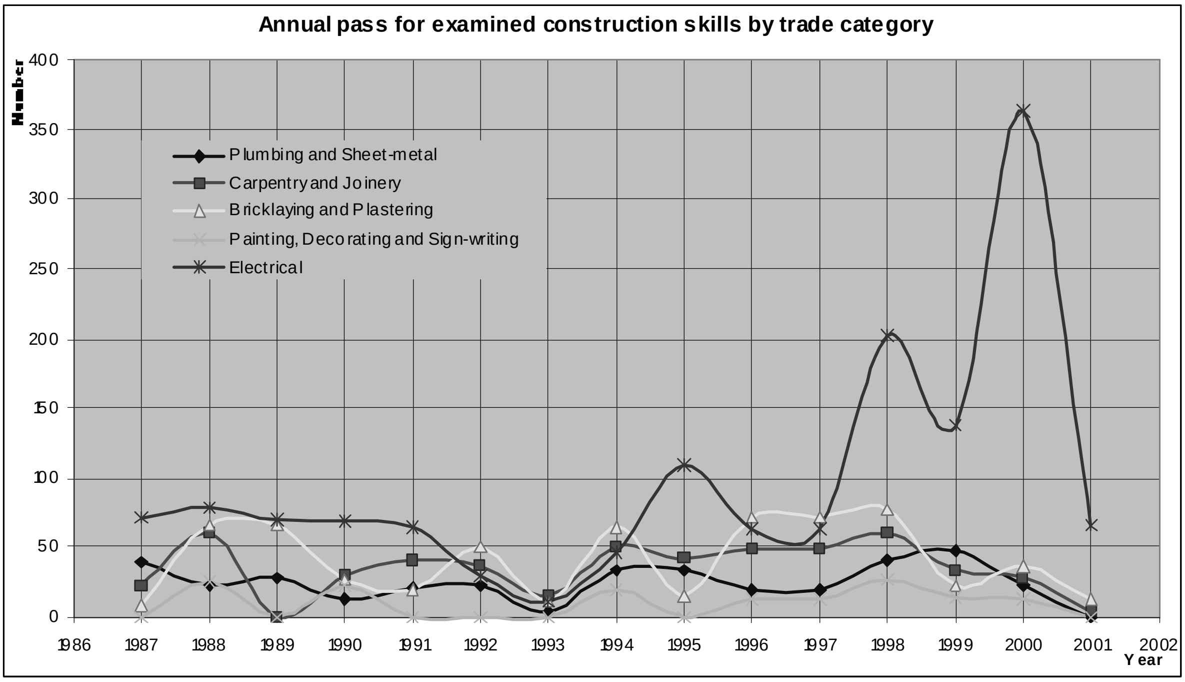
$\boldsymbol{SCI_t}$ is the skills capacity index in the period

$\boldsymbol{SS_t}$ is the skills supply in the period

$\boldsymbol{SD_t}$ is the skills demand in the period

The various values of SCI returnable from the analysis are interpreted as follows;

$\boldsymbol{SCI} \Rightarrow 0$	under capacity and constrained industry
$\boldsymbol{SCI} \Rightarrow 1$	balanced capacity industry
$\boldsymbol{SCI} > 1$	overcapacity with a supply glut



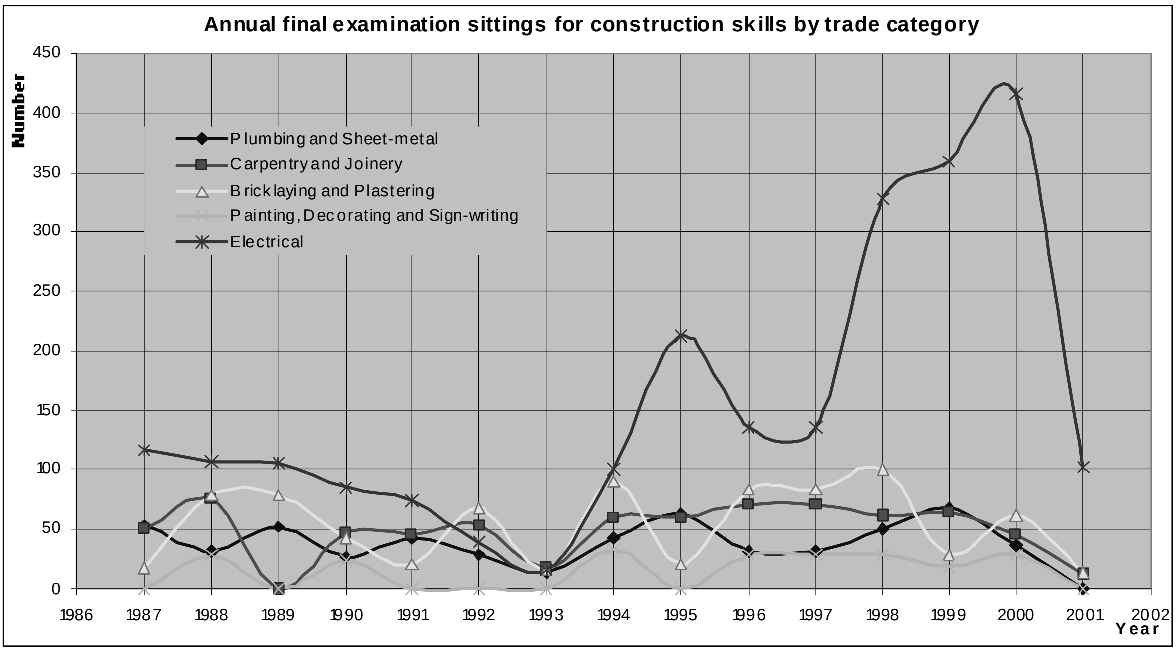
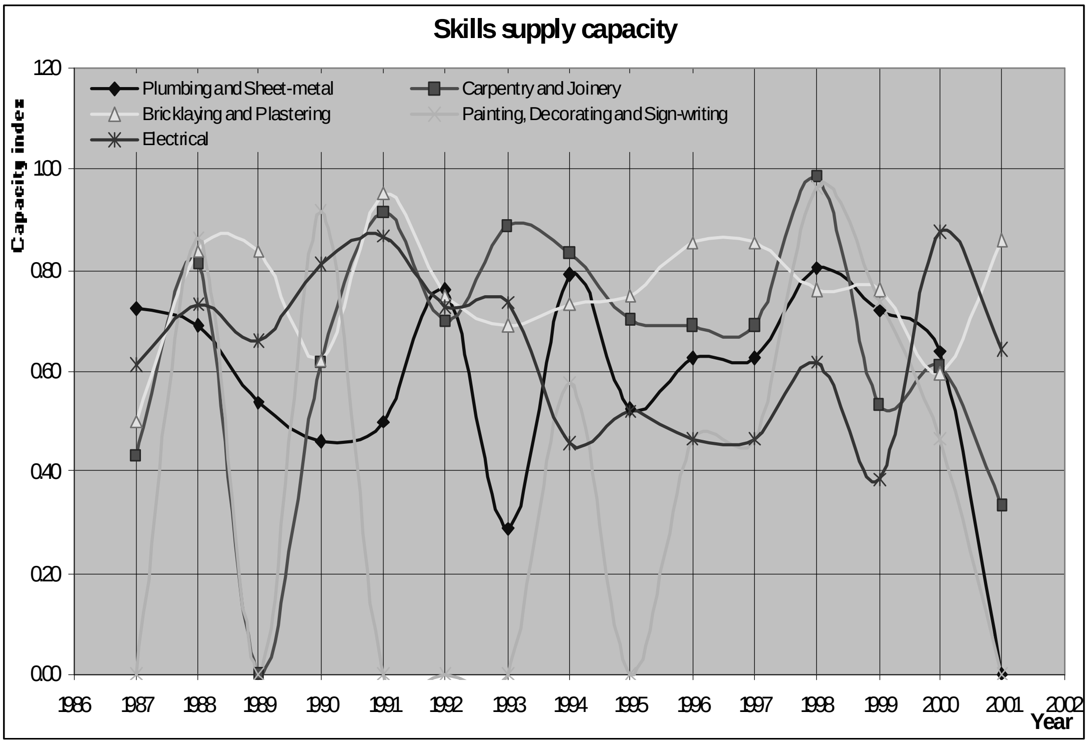


Figure 4. Skills demand profile for construction crafts in Zambia



5. Skills supply profile for construction crafts in Zambia

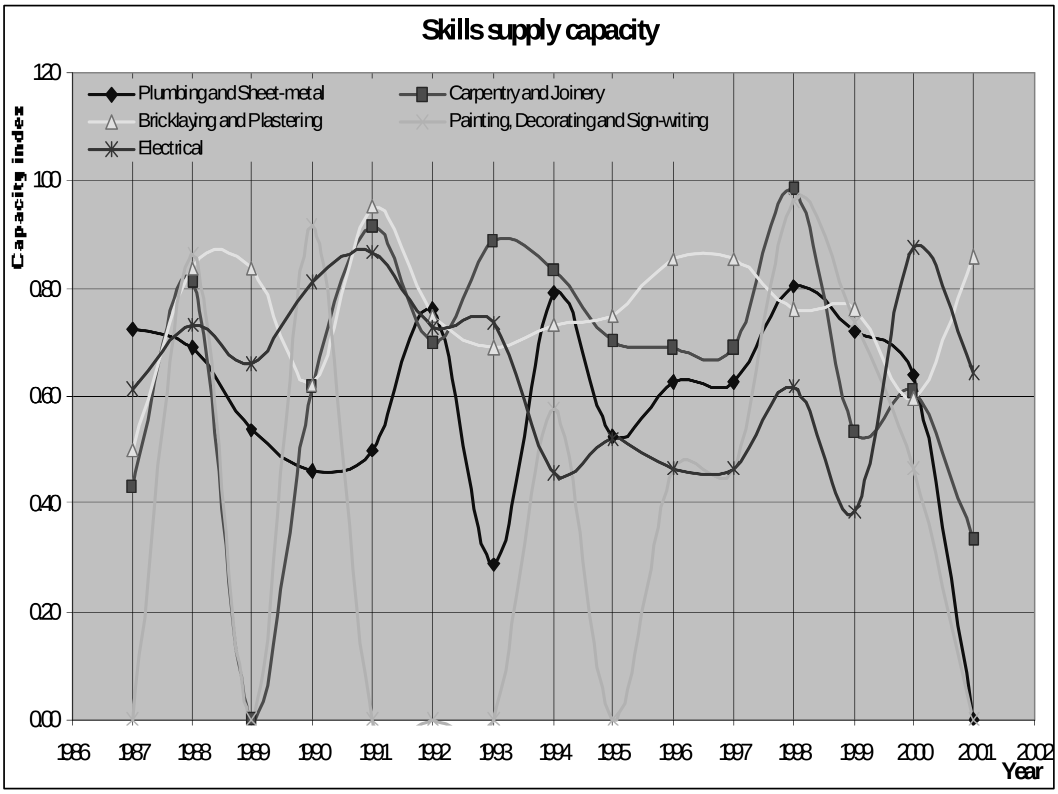


Figure 6. Skills capacity profile for construction crafts in Zambia

6. Discussion

With the exception of electrical trades there was a stable level for the demand and supply of skills in construction from 1987 to 2001. The electrical trades reflected a surge in demand and supply of skills 1998. The returned figures in 2001 for the electrical trades however, indicate that although the growth in demand and supply from 1998 was sustained over a protracted period, it could still be viewed as a noise.

The capacity indices for the different skill categories however, show a consistent under capacity with indices averaging a range between 0.4 – 0.8. In very many cases the indices closer to 0.8 reflect peaks that distort the stable trend. More recent indices closer to 2001 present a case of an exacerbating under-capacity across all the skills categories, notwithstanding the dramatic growth in numbers for the electrical trades.

The low indices across the various trade categories present a very strong case for improving the pre-examination activities for the different skills. This is would call for a greater appreciation of the conditions that influence such inefficiency. More significantly, it would be useful to conduct a similar exercise for other countries, particularly, ones' that share a similar context to enable the Zambian construction industry to assess how it measures up.

7. Conclusion

The future effectiveness of the construction industry in every country depends on the quality of the workforce it educates and trains. The analysis of the Zambian construction industry demand and supply of skills in the trade categories shows a gross under-capacity across the existing areas where training is offered. The demand supply analysis presents a method for evaluating the efficiency for developing and utilising skills in any industry or sector through the use of the skills capacity index (SCI). Such an index could also provide a basis for cross-industry comparative analysis.

Acknowledgements

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Section V

Means for improved competitiveness

Managing Preliminary Estimates in a Changing Economy

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Abstract

The accuracy of preliminary estimates has a tremendous impact on the ability of a state highway agency (SHA) to develop a functional construction budget for a given year. Consistent overestimation or underestimation of construction costs can lead to fiscal complications that may mean that a SHA is able to construct fewer projects than anticipated or fewer than otherwise possible. Fundamental economics are an additional consideration that sometimes affect both the SHA and the private contractors beyond their engineers' ability to generate accurate unit costs.

In practice, simple principles such as the level of competition, availability of work, and availability of financial resources can influence a contractor's bid price. A random sample of 100 projects per year was taken from six arbitrarily selected states over a six-year period. The engineer's preliminary estimate and the award price were recorded and the accuracy of the preliminary estimate was expressed by their difference as a percent of the estimate. The difference was then regressed against the number of bids submitted for the project, current levels of three leading economic indicators at the time of the project's letting and the state in which the project was constructed. The result of this study was a refined regression equation that predicts the accuracy of the engineer's estimate as a function of the number of bidders, some of the economic indicators, and the state.

Keywords: Preliminary, Estimate, Accuracy, Economy, Highway, Department of Transportation, Let, Letting, Prebid

1. Introduction

Managing and understanding the accuracy of preliminary estimates carry tremendous consequences for those involved in the development of the construction budget for state highway agencies (SHAs). If an agency is unable to accurately forecast the cost of constructing its projects, then it is impossible for it to develop a proper, functional budget. Several state construction budgets are now in excess of $2 billion annually. The Florida Department of Transportation (FDOT) estimates its fiscal year 2003-2004 budget to be $6.3 billion with approximately 40% or $2.52 billion going towards construction. [1] It follows that accuracy in preliminary estimation has a significant effect on citizens who fund construction through their tax dollars and who rely upon the infrastructure for their well-being.

This study analyzes data from six randomly selected states over a period of six years from 1997 to 2002. A sample of 100 projects was taken each year per state. The research team kept the ratio of bridge-to-highway-to "other" consistent from state-to-state, and the projects were chosen randomly within their category. The projects' preliminary engineer's estimate, award price, time of letting, and number of bidders were recorded. The accuracy of the estimate was measured by the award price as a percent of the engineer's estimate as seen in Equation 1. This measure is known as the "A/E Ratio."

$$\text{A/E Ratio} = (\text{Award Price}) / (\text{Engineer's Estimate})$$

Economic data including the Dow Jones Industrial Average (DJIA), Federal Funds Rate, and the Government Printing Office's (GPO) New Construction Rate were summarized and recorded by month. The accuracy of the estimate was compared to the number of bidders and the economic data through a linear multivariable regression.

2. Data Collection

2.1 Project Data

The project data, including the engineer's estimate, award price, time of letting, and number of bidders, were gathered from the Construction Office or Records and Information Office of six SHAs. Not all of the states originally contacted had the requested data available in a summarized format suitable for this study. Florida, Minnesota, Ohio, Oklahoma, North Carolina, and a Pacific Coast State (that requested not to be identified in this study) were the first SHA's able to supply compatible data. One state grouped its project letting information into years instead of months and, as a result, two separate sets of regressions were run to maintain consistent variability throughout the regressed data. Because some SHAs in practice do not accept bids outside of a 20% range of their estimate, all projects with A/E Ratios below 0.8 or above 1.2 were assumed to have contained amendments not reflected in the engineer's estimate and thus were not considered in the analysis.

2.2 Economic Indicators

Three financial indicators were selected to evaluate the economic environment at the time each project was let. The first indicator was the DJIA monthly close price. [2] The DJIA is a broad and frequently referenced indicator of the strength of the United States' economy and it is also a fair proxy for contractors' ability to procure the capital necessary to begin a project. Second, the Federal Funds Rate was used because it is a direct representation of an enterprise's ability to obtain financial capital and because it is a corollary to the strength of the general economy. The Federal Funds Rate sets a base rate for the exchange of funds between banks and it is used to establish the rate at which banks lend money to businesses and individuals. Next, the New Construction Rate was obtained from the U.S. Government

Printing Office because it is an indicator of the activity and availability of work in the construction industry. [3]

2.3 Number of Bidders

Finally, the number of contractors that submitted a bid on each project was recorded and used to indicate the level of competition. The basic principals of a free economy suggest that increased levels of competition will have an inverse effect on the price of a good or service.

3. Data Analysis

A statistical analysis of the data was performed in two stages. First, the A/E ratio, grouped by month of letting, was analyzed versus the number of bidders, monthly economic indicators, and state where the project was constructed. Second, the monthly project data was regrouped by year and combined with data from the state providing it only on an annual basis. The yearly project data were analyzed against the number of bidders, the yearly economic indicator data, and the state where it was constructed.

The statistical analysis consisted of two parts. First, the correlations between the dependent variable (A/E Ratio) and the independent variables (number of bidders, DJIA, Federal Funds Rate, new construction rate, and state) were determined to gain a basic understanding of the relationship between the variables. Second, the linear multivariable regression functions were developed and refined by removing the statistically insignificant independent variables.

General statistical analysis (Table 1) of the full monthly data indicates a significant amount of variance as shown by the standard deviation (: = 0.09100 = 9.100%) and the range between the minimum and maximum statistics for all variables. It is significant to note the mean A/E ratio (: = 0.9624 = 96.24%) is less than one. This indicates the award price was less than the engineer's estimate by an average of 3.76%. The yearly descriptive statistics are consistent with the monthly values.

These results agreed with prior research. Fisher et al. analyzed 567 projects performed by 17 companies and summarized the results of their study by stating the following:

"The community average for the actual cost versus original authorized cost is 0.92. This indicates a tendency to slightly overestimate costs and thus have a project with a cost underrun. Assuming the ideal value is 1.0, the company with the most accurate cost-estimation procedure would be the company to benchmark against in this area." [4]

Table 1. Descriptive Statistics

(A.)	N	Minimum	Maximum	Mean	Std. Deviation
A/E Ratio	1986	.80	1.20	.9624	.09100
Number of Bidders	1986	1.00	16.00	4.2296	2.06119
DJIA	1986	6583.48	11497.12	9718.9584	1233.86838
Federal Funds Rate	1986	1.73	6.54	4.9735	1.26221
New Construction Rate	1986	577.10	881.60	756.4639	95.32818

(B.)	N	Minimum	Maximum	Mean	Std. Deviation
A/E Ratio	2931	.80	1.20	.9614	.09199
Number of Bidders	2931	1.00	17.00	4.3091	2.18418
DJIA	2931	7437.57	10688.04	9434.0387	1148.96420
Federal Funds Rate	2931	1.67	6.24	4.6233	1.46370
New Construction Rate	2931	653.40	860.90	777.4132	77.01802

3.1 Correlations

Pearson Correlation data was taken from the correlation table generated by the SPSS statistical software package (Table 2). The analysis shows the strongest relationship exists between the A/E ratio and the number of bidders. The number of bidders along with the DJIA and new construction rate showed a negative coefficient of correlation indicating an inverse relationship. The federal funds rate showed a positive coefficient indicating a direct relationship. The magnitudes of the Pearson coefficients, however, indicate low correlations between all independent variables except for the number of bidders.

Table 2. Correlation Tables

Monthly Data		AE Ratio
A/E Ratio	**Pearson Correlation**	1
	Sig. (2-tailed)	.
	N	1986
Number of Bidders	**Pearson Correlation**	-.230
	Sig. (2-tailed)	.000
	N	1986
DJIA	**Pearson Correlation**	-.068
	Sig. (2-tailed)	.003
	N	1986
Federal Funds Rate	**Pearson Correlation**	.055
	Sig. (2-tailed)	.015
	N	1986
New Construction Rate	**Pearson Correlation**	-.061
	Sig. (2-tailed)	.006
	N	1986

3.2 Monthly Regression

Although only one independent variable, the number of bidders, showed a significant Pierson Coefficient of Correlation, all independent variables were used in the initial regression.

The initial regression had an adjusted $R^2$of 0.066 indicating that 6.6% of the variance in the dependent variable (A/E ratio) is explained by the independent variables (number of bidders, DJIA, Federal Funds rate, new construction index, and the state where the project was constructed) used in the regression equation (Table 3).

The initial regression equation can be written as a single equation (Equation 2) with values of zero or one used for the state variables (where a value of one indicates the project was built in that state). The results of the regression can also be written as a series of equations (Equations. 3-7) specific to each state where values of zero and one are already entered where appropriate and the equation is simplified by combining the constants.

Table :. Evaluation of First Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.264(a)	.070	.066	.08795
Predictors: (Constant), Number of Bidders, DJIA, Federal Funds Rate, New Construction Rate, State 6, State 4, State 3, State 2				

$Y = .996 - (.009)x_1 - (3.623*10^{-6})x_2 + (.005)x_3 + (1.102*10^{-5})x_4 + (.009)x_5 - (.009)x_6 + (.005)x_7 + (.019)x_8$

$Y = .996 - (.009)x_1 - (3.623*10^{-6})x_2 + (.005)x_3 + (1.102*10^{-5})x_4$ Florida

$Y = 1.005 - (.009)x_1 - (3.623*10^{-6})x_2 + (.005)x_3 + (1.102*10^{-5})x_4$ Minnesota

$Y = .987 - (.009)x_1 - (3.623*10^{-6})x_2 + (.005)x_3 + (1.102*10^{-5})x_4$ Ohio

$Y = 1.001 - (.009)x_1 - (3.623*10^{-6})x_2 + (.005)x_3 + (1.102*10^{-5})x_4$ Oklahoma

$Y = 1.015 - (.009)x_1 - (3.623*10^{-6})x_2 + (.005)x_3 + (1.102*10^{-5})x_4$ North Carolina

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the DJIA, X_3 is the Federal Funds Rate, X_4 , is the new construction rate, and X_5, X_6, X_7, and X_8 are equal to one if the project was constructed in Minnesota, Ohio, Oklahoma, and North Carolina respectively.

At an alpha level (") of 0.10 only three of the regression coefficients are significant to the model. The number of bidders, federal funds rate, and State 6 (North Carolina) had p-values (Table 4) less than alpha so a second regression was run with only these independent variables.

3.3 Refined Monthly Regression

The second regression had a R^2 of 0.062 indicating that 6.2% of the variance in the dependent variable (the A/E ratio) is explained by the three remaining independent variables (number of bidders, Federal Funds rate, and State 6) used in the regression equation (Table 5). All of the remaining variables had p-values less than alpha (Table 6) indicating that they were significant to the regression model.

TABLE 4. First Monthly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	(P-value)
		B	Std. Error	Beta		
1	**(Constant)**	.996	.022		45.777	.000
	Number of Bidders	-.009	.001	-.207	-9.321	.000
	DJIA	-3.623E-06	.000	-.049	-1.249	.212
	Federal Funds Rate	.005	.002	.069	2.835	.005
	New Construction Rate	1.102E-05	.000	.012	.286	.775
	State 2	.009	.007	.043	1.435	.151
	State 3	-.009	.007	-.035	-1.247	.213
	State 4	.005	.007	.022	.786	.432
	State 6	.019	.006	.096	3.045	.002
a Dependent Variable: A/E Ratio						

TABLE 5. Evaluation of Refined Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.252(a)	.064	.062	.08813
a Predictors: (Constant), Federal Funds Rate, Number of Bidders, State 6				

TABLE 6: Refined Monthly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	(P-value)
		B	Std. Error	Beta		
1	**(Constant)**	.976	.009		104.623	.000
	Number of Bidders	-.010	.001	-.219	-9.976	.000
	State 6	.018	.004	.088	4.006	.000
	Federal Funds Rate	.004	.002	.062	2.827	.005
a Dependent Variable: A/E Ratio						

The refined regression can, again, be expressed as a single equation (Equation 8) or as a state-specific equation (Equation 9). States without a specific regression equation do not vary significantly from the general regression model and the general equation should be used for purposes of analysis of data from these states.

$Y = .976 - (.010)x_1 - (.004)x_2 + (.018)x_3$ General Eqn.

$Y = .994 - (.010)x_1 - (.004)x_2$ North Carolina

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the Federal Funds rate, and X_3 is State 6 (North Carolina).

3.4 Simple Monthly Regression

In practice, it is commonly understood in the construction industry that projects with a high number of bidders tend to be bid at a lower price. In order to estimate the impact of this study's consideration of additional economic indicators and state-specific adjustments, a simple linear regression was run with only the number of bidders.

The simple regression had a R^2 of 0.053 indicating that 5.3% of the variance in the dependent variable (the AE ratio) is explained by the number of bidders (Table 7). Given that there are an almost infinite number of variables that can affect the accuracy of a preliminary estimate, a low R^2 was expected. The fact that the R^2 equals 5.3% with "number of bidders" as the only independent variable and only 6.2% with all of the other variables added shows that the number of bidders alone accounts for about 85% of the R^2 of the general equation. This, along with the extremely high number of variables makes the number of bidders a statistically significant factor in the accuracy of preliminary estimates given the sample tested. The size of the sample also lends credence to this conclusion. [5]

Table 7. Evaluation of Simple Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.230(a)	.053	.052	.08858
a Predictors: (Constant), Number of Bidders				

The simple regression equation (Equation 10) expresses the A/E Ratio, Y, as a function of the number of bidders, X_1.

$Y = 1.005 - (.010)x_1$ General Eqn.

3.5 Yearly Regression

All independent variables were again used in the initial yearly regression. The initial regression of the yearly data had an adjusted R^2 of 0.065 indicating that 6.5% of the variance in the dependent variable (A/E ratio) is explained by the number of bidders, DJIA, Federal Funds rate, New Construction Index, and state variables used in the regression equation. (Table 8)

Table 8. Evaluation of First Yearly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.260(a)	.067	.065	.08898
a Predictors: (Constant), North Carolina, New Construction Rate, Number of Bidders, Minnesota, Ohio, Oklahoma, Federal Funds Rate, Pacific Coast State, DJIA				

As explained in the monthly regressions, the initial regression equation can be written as a single equation (Equation. 11) with values of zero or one used for the state variables (where a value of one indicates the project was built in that state) or as a series of state specific equations (Equations. 12 - 17).

$Y = .989 - (.009)x_1 - (1.006*10^{-5})x_2 + (.006)x_3 - (.018)x_6 - (.009)x_7 + (.002)x_8 + (.011)x_9$

(variables x4 + x5 had a coefficient of 0.00 so they were removed from equation 5.1)

$Y = .989 - (.009)x_1 - (1.006*10^{-5})x_2 + (.006)x_3 + (0.00)x_4$ Florida

$Y = .989 - (.009)x_1 - (1.006*10^{-5})x_2 + (.006)x_3 + (0.00)x_4$ Minnesota

$Y = .971 - (.009)x_1 - (1.006*10^{-5})x_2 + (.006)x_3 + (0.00)x_4$ Ohio

$Y = .980 - (.009)x_1 - (1.006*10^{-5})x_2 + (.006)x_3 + (0.00)x_4$ Oklahoma

$Y = .991 - (.009)x_1 - (1.006*10^{-5})x_2 + (.006)x_3 + (0.00)x_4$ Pacific Coast State

$Y = 1.00 - (.009)x_1 - (1.006*10^{-5})x_2 + (.006)x_3 + (0.00)x_4$ North Carolina

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the DJIA, X_3 is the Federal Funds Rate, X_4 is the New Construction Index, and X_5, X_6, X_7, X_8, and X_9 are equal to one if the project was constructed in Minnesota, Ohio, Oklahoma, a Pacific Coast State and North Carolina respectively. At an alpha level (") of 0.10, five of the nine regression coefficients are significant to the model. The number of bidders, DJIA, federal funds rate, and States 3 and 6 (Ohio and North Carolina) had p-values (Table 9) less than alpha so a second regression was run with these independent variables.

Table 9. First Yearly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig. (P-value)
		B	Std. Error	Beta		
1	**(Constant)**	.989	.030		33.275	.000
	Number of Bidders	-.009	.001	-.213	-11.627	.000
	DJIA	-1.006E-05	.000	-.126	-3.046	.002
	Federal Funds Rate	.006	.002	.099	3.003	.003
	New Construction Rate	.000	.000	.085	1.731	.083
	Minnesota	.000	.006	.002	.071	.943
	Ohio	-.018	.006	-.074	-3.150	.002
	Oklahoma	-.009	.006	-.034	-1.454	.146
	Pacific Coast State	.002	.006	.006	.267	.789
	North Carolina	.011	.006	.045	1.879	.060

a Dependent Variable: A/E Ratio

3.6 Refined Yearly Regression

The second regression had a R^2 of 0.064 (Table 10) indicating that 6.4% of the variance in the AE ratio is explained by the remaining independent variables (the number of bidders, DJIA, federal funds rate, and States 3) and 6) used in the regression equation (Table 11).

Table 10. Evaluation of Refined Yearly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.255(a)	.065	.064	.08902
a Predictors: (Constant), North Carolina, DJIA, Federal Funds Rate, Number of Bidders, Ohio				

The refined regression can, again, be expressed as a single equation (Equation 18) or as a state-specific equation (Equations 19, 20) when the state regression varies significantly from the general regression model.

Table 11. Refined Yearly Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig. (P-value)
		B	Std. Error	Beta		
1	(Constant)	1.032	.015		70.496	.000
	Number of Bidders	-.009	.001	-.208	-11.532	.000
	DJIA	-4.998E-06	.000	-.062	-3.481	.001
	Federal Funds Rate	.003	.001	.050	2.819	.005
	Ohio	-.016	.005	-.067	-3.635	.000
	North Carolina	.012	.004	.053	2.868	.004
a Dependent Variable: A/E Ratio						

$$Y = 1.032 - (.009)x_1 - (4.998*10^{-6})x_2 + (.003)x_3 - (.016)x_4 + (.012)x_5 \quad \text{General Eqn.}$$
$$Y = 1.016 - (.009)x_1 - (4.998*10^{-6})x_2 + (.003)x_3 \quad \text{Ohio}$$
$$Y = 1.044 - (.009)x_1 - (4.998*10^{-6})x_2 + (.003)x_3 \quad \text{North Carolina}$$

Where Y is the A/E ratio, X_1 is the number of bidders, X_2 is the DJIA, X_3 is the Federal Funds rate, and X_4 and X_5 are States 3 and 6 (Ohio and North Carolina) respectively.

3.7 Simple Yearly Regression

Again, in order to gauge the impact of this study's consideration of additional economic indicators a simple linear regression was run with only the number of bidders. The simple regression had a R^2 of 0.050 indicating that 5.0% of the variance in the dependent variable (the A/E ratio) is explained by the number of bidders (Table 12).

Table 12. Evaluation of Simple Monthly Regression Model Fit

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.224(a)	.050	.050	.08967
a Predictors: (Constant), Number of Bidders				

The simple regression equation (Eqn. 21) expresses the A/E Ratio, Y, as a function of the number of bidders, X_1.

$Y = 1.002 - (.009)x_1$ General Eqn.

4. Application of Equations

The refined regression equations can be used alone or in a confidence interval to predict expected values for estimation accuracy in individual projects. In practice, a budgeting officer in a SHA would input the appropriate economic and state data into the regression equation and record the A/E ratio it generates. The budgeting officer would then adjust the engineer's estimate by multiplying the engineer's estimate for the project by the A/E Ratio predicted by the regression equation as shown in Equation 22.

Adjusted Estimate = (A/E Ratio)(Engineer's Estimate)

5. Validation of Equations

Both the monthly and yearly regression models had low R^2. In the refined regression models this indicates that only 6.2% (monthly) and 6.4% (yearly) of the variance in the percent difference between estimates (A/E Ratio) is explained by the variance of the independent variables. From a purely statistical perspective these values are quite low. However, because of the many other extraneous factors that lead to errors in project estimation, a low value of R^2 was expected and does not in any way detract from the value of the model, as explained earlier. The more important question is whether use of the model increases the accuracy of preliminary estimates.

By applying the regression equation to make adjustments on the project estimates used in this study it can be shown that this model significantly improves the accuracy of the engineer's estimate. Further, the fully adjusted regression equations that include all

significant variables provide a greater reduction in the spread (error) between the engineer's estimate and the award price than both the unadjusted estimate and the

estimate adjusted by only considering the number of bidders. This can be observed by comparing the difference between the engineer's estimate and the award price with the difference between the fully adjusted engineer's estimate (considering all significant economic and state data) and award price, and with the engineer's estimate adjusted by the number of bidders and the award price.

The sums of the absolute values of these errors for each state during the six years considered in this study are seen in Table 13.

Table 13. Results of Using Correction Algorithms

Method of Adjustment (Model)	Sum of Errors, All Six States
Unadjusted Estimate	$234,850,879
Fully Adjusted	$ 59,532,648
Adjusted Only With Number of Bidders	$ 79,079,338

Note the fully-adjusted estimate has the lowest error value. Conversely, the straight sum of the errors for all years considered in this study allows the overestimations and underestimations to balance out resulting in the "number of bidders" regression providing the greatest reduction in error. However, the fully-adjusted regression provides better results when considering the standard deviation. The fully adjusted models for both the monthly and yearly regressions show standard deviations lower than the standard deviations for the "number of bidders" regression. This helps explain why when each state is considered individually the fully adjusted regression most frequently provides the smallest error of the three models.

6. Summary and Conclusions

A study was conducted using relevant data from approximately 3600 highway construction projects. The goal was to measure the accuracy of the preliminary estimates of six SHAs and, using statistical analysis, develop an algorithm that can be used by SHAs to improve the accuracy of their preliminary estimates.

There was great statistical similarity between the states in their ability to accurately estimate the cost of highway construction projects. The result of the analysis on the accuracy rate of the different state DOTs in preliminary estimates agreed with recognized prior research. Details of this portion of the research is beyond the scope of this paper.

A preliminary estimate accuracy model was derived by use of accepted statistical regression practice. Several potential "predictors" were analyzed and the ones that contributed to improved accuracy were retained in the equation as independent variables. The original list of potential predictors included the number of bidders and three leading economic indicators, the DJIA, the Federal Funds Rate, and the New Construction Rate. The number of bidders was, by far, the predictor that had the greatest impact on the models' performance, but the most accurate model included all four of these, plus the states, as independent variables.

When each state is considered individually, as would be done in practice, two models, the one using only the number of bidders, and the fully-adjusted regression model provided significant improvements in accuracy of the engineer's estimate, though no model was able to achieve a reasonably high R^2. The fully-adjusted model performed somewhat better than the one using only the number of bidders. Of course, any agency using this model should use their own historical data to determine which variables to include in their customized equation. In any event, the fact that either of these two models can be used to improve a DOT's preliminary estimate accuracy overrides concerns about the low R^2. What the low R^2 does, however, is point to the probability that some other variable or variables may be discovered with future research that would improve the performance of the model. The research team will continue to search for those variables.

Also of interest was the finding that none of the economic indicators proved to be consistently statistically significant to the accuracy of preliminary estimates. Given the fact that the U.S. economy experienced both a boom and a recession during the time period of this study, it can be inferred that the state of the economy does not have a significant effect on the accuracy of preliminary estimates.

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Cost Savings of Long-Term Performance-Based Maintenance Partnering

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Abstract

Dutch housing associations are for many reasons considering the application of performance-based maintenance partnership forms. With this they expect to manage maintenance processes efficiently and effectively.

If a contract is performance-based, the contractor has contract-related incentives to improve its way of working in terms of performance. That will result in direct and indirect cost-savings. Direct project costs represent the expenditure incurred during the actual performance of (long-term) maintenance activities. The indirect project costs are all costs in connection with the organization and performance of the maintenance activities, but which cannot be expressed as direct project costs. In other words, these are the process costs incurred by both client and contractor.

Indirect cost reductions can be realized because the long-term performance-based approach enables maintenance contractors to assume responsibility for certain activities which they are better equipped to perform than their clients. In the traditional approach, many activities are duplicated, i.e. conducted by both client and contractor, because information is lost following the once-only tendering process. In the performance-based approach, clear agreements are made with regard to which party is responsible for which activity during the cooperation period.

Ten projects show that the total indirect costs are lower in the performance-based approach than in the traditional working method. The costs of the initial processes in half of the projects are higher in the performance-based approach than in the traditional approach. The ‘Evaluation and After-care’ phase is more expensive in every project when using the performance-based approach. The fact that the indirect costs of the performance-based approach are lower overall than those of the traditional approach is entirely due to the reduction achieved in the subsequent phases. The performance-based approach offers the lowest indirect costs to the client. It offers not only a financial advantage in the subsequent processes, but in the initial process too. The indirect costs to the contractor are also lower in the performance-based approach than in the traditional working method, although the savings are somewhat more modest than those enjoyed by the client.

Keywords: cost-savings, long-term co-operation, maintenance, partnering, performance-based

1. Introduction

The professionalism of Dutch housing associations have led to a noticeably greater attention for maintenance processes and partnership forms in the supply chain for maintenance [3, 6, 7]. The growth in the size of the holdings for which an individual housing association is responsible is an important factor in considering the adoption of performance-based partnership forms for maintenance. Some larger housing associations have as many as 40,000 dwellings under their management, which renders it more or less essential to explore alternative means whereby maintenance processes can be managed efficiently and effectively. An additional factor is that the housing associations have chosen to re-focus on their core business, and a number now regard maintenance as a secondary process for which outsourcing, provided it is organized in a responsible manner, is preferable. Another reasons for considering performance-based partnering is the emergence of a strategic housing stock policy and the adoption of quality management systems. The appropriate partnership forms for a housing association depends on its size, organisational structure, business-like approach, the type of maintenance and building components involved and especially its goals for partnering.

In the traditional approach, tendering is a multiple, competitive process. Dutch housing associations generally invite three to five maintenance contractors an offer, based on technical specifications of the work. These contractors act as suppliers of capacity. By contrast, in the performance-based approach, it is assumed that the client conducts a single-phase tendering procedure. The performance-based approach centres on a set of desired performances. Maintenance contractors become active participants in the overall maintenance process. They assume certain risks and responsibilities with regard to the quality and costs of maintenance activities, doing so for a long period wherever possible.

Both clients and contractors cite a number of disadvantages attaching to the traditional process and advantages attaching to new procurement methods [8]. Clients emphasise the reduction of financial risks at the longer term and steering the maintenance processes on main points by a long-term performance-based agreement. Contractors underline improvements of performance and service and innovations in the whole maintenance process by having continuity in orders and sustainable relationships with clients. Self-motivation of contractors to increase performance is essential [2].

2. Research project

The OTB Research Institute for Housing, Urban and Mobility Studies, which is part of Delft University of Technology in the Netherlands, is doing research to the application of performance-based maintenance agreements by Dutch housing associations. The research project is entitled 'Performance-based cooperation in the technical management of housing stock'. Main Dutch housing associations, real estate maintenance contractors and branch organisations contribute to this project, which consist of several ongoing studies.

One study is into performance-based maintenance agreements for several building components and organization's maintenance activities and involves seven large, innovative housing associations and the Dutch Building Research Foundation (SBR). The study involves input from consultants and contractors specializing in exterior surfaces. Clients and contractors require guidelines for an effective, efficient and transparent performance-based procurement processes and agreements. OTB Research Institute is working alongside the parties concerned in developing appropriate guidelines, with a focus on exterior surfaces and flat roofing. Those guidelines consist of flow charts and decisive performance requirements [8].

Another study is into direct and indirect cost savings by performance-based long-term cooperation between clients and contractors [7]. A breakthrough of performance-based maintenance agreements is obstructed by a lack of knowledge of clients and contractors, desired flexibility in maintenance policy by clients and their desired low market prices. In many cases the contract period is restricted to a maintenance interval, this being the period between the two years in which planned maintenance activities are scheduled.

Long-term, performance-based cooperation offer many advantages compared to the traditional tendering approach. One of the main benefits is that long-term performance-based cooperation is likely to reduce both direct and indirect costs. The essential preconditions are long-term involvement and freedom in the maintenance design and process, giving opportunities for product and maintenance process improvements and innovations.

The OTB Research Institute for Housing, Urban and Mobility Studies was asked by the WVB, a Dutch federation of property maintenance companies, to conduct a cost comparison of long-term performance-based cooperation against the traditional approach. The study distinguishes between direct and indirect cost components, and identifies both direct and indirect cost reductions. The research question was: what are the costs for both client and contractor when conducting exterior maintenance on a number of building complexes over a period of at least two maintenance intervals, comparing such costs under a long-term performance-based cooperation between client and contractor to those incurred when using the traditional method? The study involved modelling and case studies. The first step in the research was to develop calculation models that would compare the direct and indirect project costs of each method at individual project level. These models are based upon knowledge about the maintenance procurement processes, the traditional approach and the long-term performance-based co-operation form, and upon the flow charts of these processes developed in the related study.’

The outcome of the research will assist in discussions around the transition of the building sector from a one-dimensional orientation on costs, to process and value maximization. Therewith, impetus to unwelcome cooperation between building contractors in tendering processes can decrease [1].

2.1 Case studies

In order to make a thorough comparison of the direct and indirect maintenance costs involved in each method, ten actual cases were studied. Each case involves exterior maintenance of housing blocks owned and managed by a housing association. Presumably the size and scope of the project will influence the direct and indirect project costs. Here, a distinction was made between ‘simple’ and ‘complex’ projects, depending on the scope and type of maintenance work involved, and the lead-time of the (initial) process.

The cases studied vary in terms of the characteristics of each housing block, size, maintenance history and original quality, the working methods of client and contractor, etc. Accordingly, they are not directly comparable one against the other. However, each case enables a comparison to be made between the long-term performance-based and traditional approach in terms of direct and indirect project costs.

The cost comparison assumes a performance-based working method, with the applicable basic premises in terms of level of quality and maintenance period. The contactors will have produced a maintenance scenario for this period, together with the relevant costing and budget. The notional direct and indirect costs of the traditional working method can be closely estimated, based on the quality level and maintenance period. The maintenance history of the building will play a significant part here. It is assumed that the direct costs of painting – including preventative maintenance work – are cyclically recurrent.

3. Traditional contracting and long-term co-operation

Traditionally technical specifications are formulated by the housing association, being the basis of the multi-tendering process. The housing association supervises the maintenance work in detail. A final acceptance control also involves an examination of performance directly related to the quality of the workmanship. Measurement of client satisfaction might be done by the housing association.

In a long-term performance-based cooperation form the housing association and the maintenance contractor jointly specify decisive performance requirements for several housing complexes (housing blocks), concluded in a framework agreement [6]. The contract duration is a maintenance scenario covering several maintenance intervals, eventually lasting the expected exploitation period of a housing complex.

The contractor works out the desired performances, fitting them into the actual technical state of the housing complex and the expected service life. The technical solutions are laid down in maintenance scenarios and activity plans. A maintenance scenario covers several intervals of returning maintenance interventions, for example paintwork. The best maintenance scenario is chosen, based upon net present values and total costs of ownership. The scenario and the performance criteria are laid down in a performance agreement. In a performance-based partnership form the primary purpose of control and supervision by the housing association is to review the performance achievements and to identify problems with the necessary action. The contractors themselves monitor the degradation processes of building components by performing performance measurements. In case of fabric maintenance and paintwork this may for example concern the cracking of substrates and the degree of blistering of paints. They also monitor the process and especially the customers satisfaction during maintenance interventions and thereafter. They keep responsibilities for laid down performances and client satisfaction during the contract period. Performance control by independent third parties, may take the form of a random check rather than a full inspection of all performance criteria. During the contract period the maintenance scenario might be adapted. The housing association’s objectives are likely to change over time, just as external circumstances may change.

Flow charts are presented to depicture the process steps that have to be taken by housing associations and maintenance contractors when pursuing performance-based co-operation. Figure 1 gives a picture of the traditional procurement process model, used as a reference model. Figure 2 gives a picture of performance-based cooperation for maintenance.

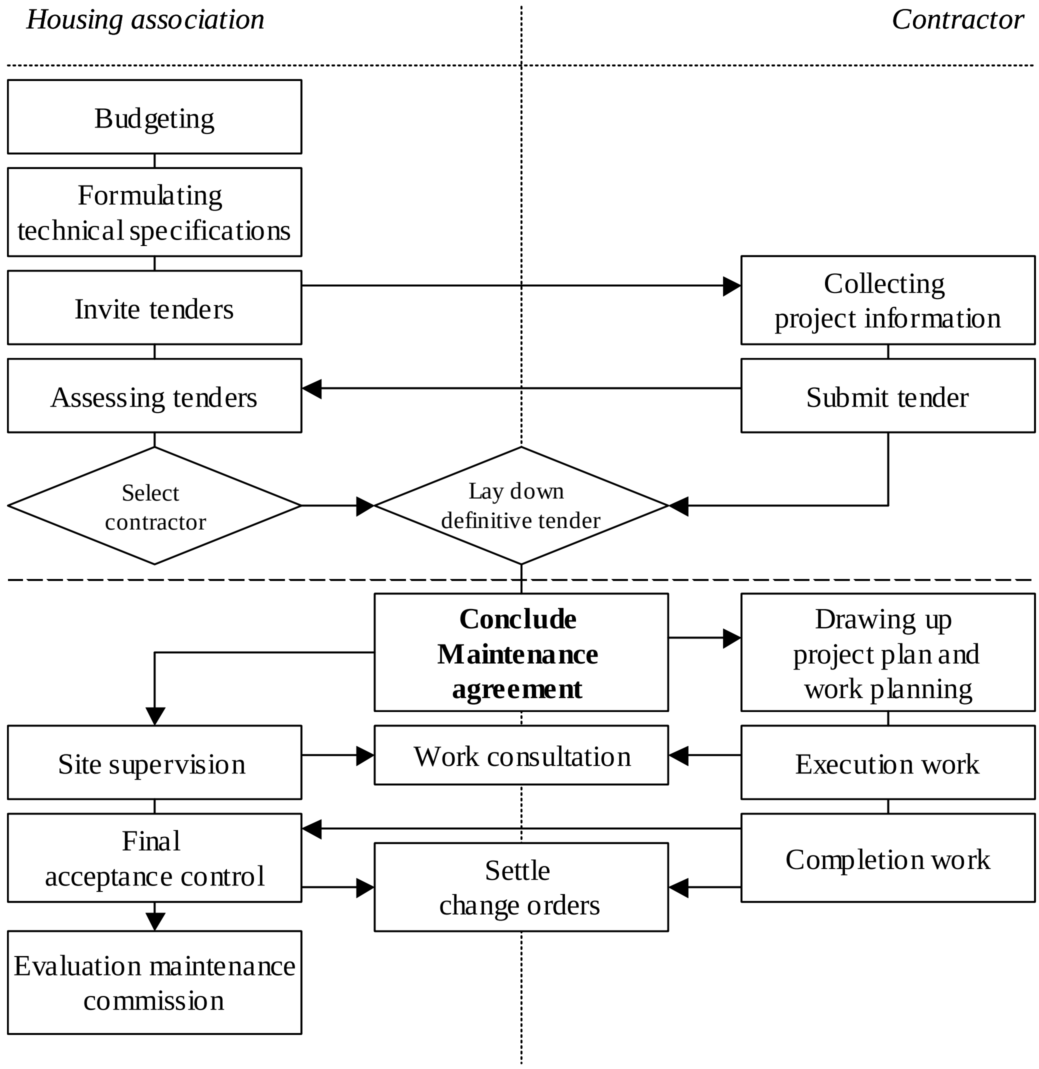

Figure 1 Process model traditional approach

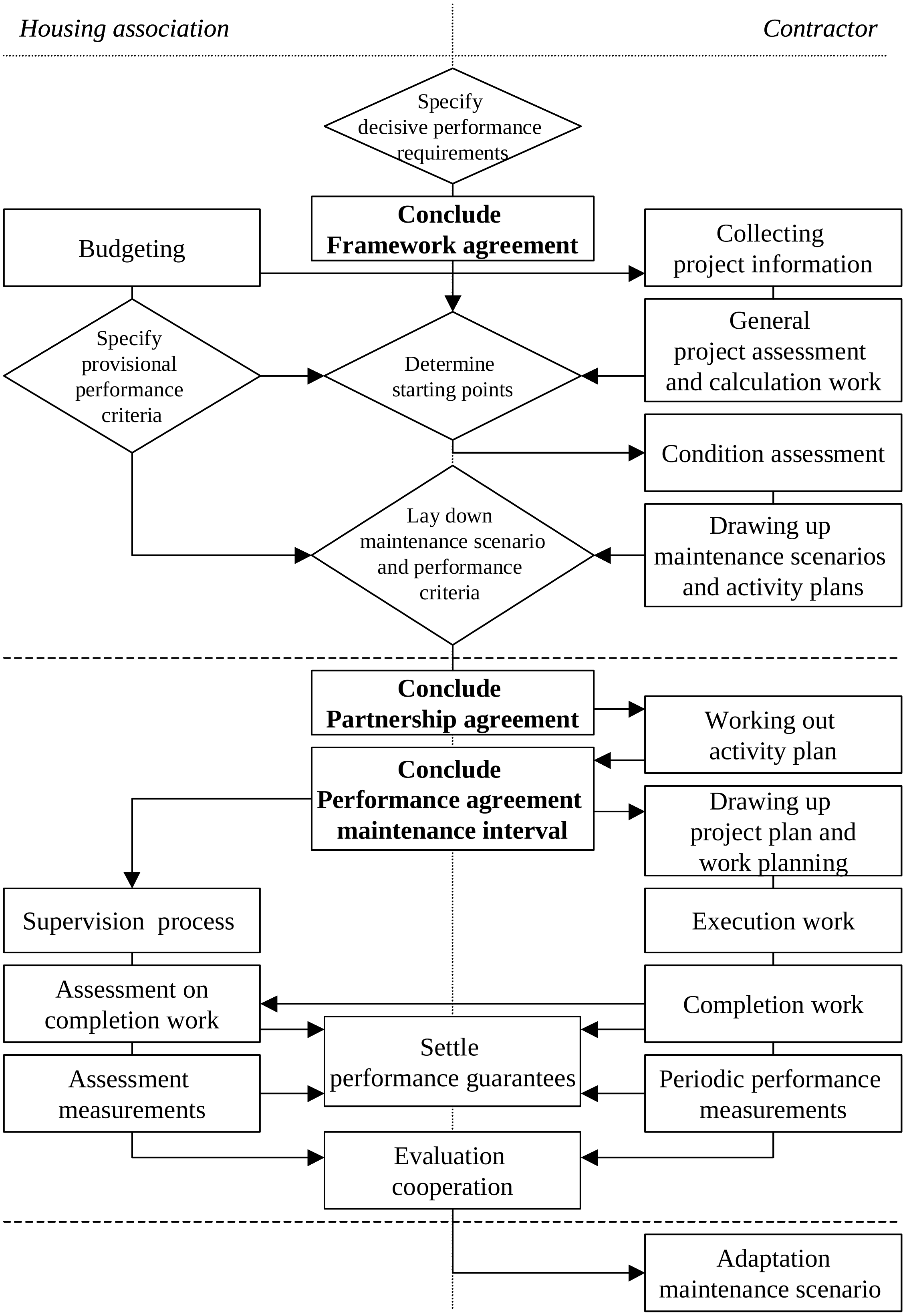

Figure 2: Long-term performance-based cooperation

4. Indirect costs model

Direct project costs represent the expenditure incurred during the actual performance of (long-term) maintenance activities. The indirect project costs are all costs in connection with the organization and performance of the maintenance activities, but which cannot be expressed as direct project costs. In other words, these are the process costs incurred by both client and contractor. Third parties, such as consultants or inspection agencies, may perform some activities, the costs involved being charged to the client and/or contractor. For the client, the overall maintenance costs consist of the direct and indirect project costs for the (long-term) performance of maintenance activities, together with the project-related costs of the services of consultants or inspection agencies, where these are not included in the direct or indirect costs.

Table 1: Schedule of activities calculation model indirect costs, initial process

	Traditional		**Performance-based**	
	Client	**Contractor**	**Client**	**Contractor**
Specification, Selection and Contracting				
Budgeting				
Formulating technical specifications				
Formulating performance criteria				
Invite tenders contractors				
Collecting and collating project information				
Condition assessment				
Reporting condition assessment				
Collecting external advice				
Consultation				
Drawing up maintenance scenarios				
Invite tenders subcontractors				
Assessment bids subcontractors				
Calculation maintenance scenario				
Formulating bid				
Assessment bids contractors				
Cancel contractors				
Consultation				
Assign work				
Confirm work				
Work and Supervision				
Drawing up project plan and work planning				
Reporting work				
Work consultation				
Site supervision				
Supervision process				
Consultation and information tenants				
Supervision process				
Final acceptance control				
Reporting completion work				
Settle change orders				
Evaluation and After-care				
Evaluation process				
Assessment customer satisfaction				
Performance measurement				
Reporting performance measurements				
Consultation performance measurement				
Settle performance guaranties				
Subsequent calculation				

In practice, it has proven somewhat difficult to identify the indirect costs involved in the traditional and performance-based working methods according to the above definitions. This is because these costs are generally incorporated in the bid price, perhaps by means of underlying unit prices. This applies not only to the process costs previously mentioned, but also the indirect costs for secretarial support, purchasing of material, taking stock, etc. In fact, these non-process-related indirect costs will be approximately the same for both the traditional and performance-based working approach. For pragmatic reasons, it was therefore decided to base the direct costs on the tender price of each method. The bid price is therefore assumed to include all project-related indirect costs. In addition, a separate comparison of the indirect process costs for each method was made.

4.1 Calculation models

Calculation models were produced to render the direct and indirect project costs visible. The calculation model for the direct costs enables the direct long-term maintenance costs at project level to be determined on the basis of both the traditional and the performance-based approach.

The indirect project costs will depend on the process activities that must be conducted by the client and contractor respectively throughout the maintenance period of the complex. The initial process and the subsequent processes consist of all activities conducted during a maintenance interval. Following the initial process, one or more subsequent processes will take place. It is assumed that these subsequent processes will be equal in scope and cost, although the actual maintenance activities undertaken in each can of course vary.

The activities in the initial and subsequent processes can be clustered into three phases (see Table 1):

- Specification, selection and contracting;
- Work and supervision;
- Evaluation and after-care.

The indirect cost model is based on a differentiation in hourly charges per activity, with the level of charges depending on the various wage scale groups applied by both client and contractor. The model assumes that each party will have three such groups.

In calculating the net present value of both direct and indirect project costs, the study took into account both the annual price rises due to inflation and the relevant depreciation factor.

5. Anticipated cost reductions

5.1 Direct cost reductions

The direct cost savings offered by long-term performance-based maintenance cooperation can be realized by:

- planning the maintenance activities according to the existing level of quality, the desired performance level and the service life of a housing complex, taking performance degradation into account;
- conducting maintenance activities on a 'just-in-time' or 'condition-based' basis, according to the agreed performance level ;
- ensuring better coordination between work to the substrates and to the finishing (e.g. undercoats and final painting).

A performance-based cooperation form offers a better guarantee of actually achieving the advantages of condition-based maintenance than the traditional approach, since it is the contractor who conducts the performance measurements and who also bears the risks relating to the timely performance of maintenance activities. The deterioration can be predicted more accurately, and hence the controllability of costs is enhanced. In the initial process, a thorough analysis of the causes of defects will be conducted. During the maintenance period, the performance level will be monitored by means of performance measurements. Based on these measurements, the maintenance activities will be carried out 'just-in-time'.

The performance-based method offers the contractor greater opportunities to coordinate the maintenance activities to the requirements of the client during the duration of the maintenance period, and to coordinate maintenance activities with each other. This is the result of the contractor's long-term involvement in, and responsibility – including financial responsibility – for the maintenance project under the performance-based partnering agreement. The fact that the same contractor is responsible for both the paintwork and maintenance work to the substrates is also important. The contractor will select the solution offering the lowest costs over the entire service life. In the traditional approach, this service-life cost approach is more difficult [4]. It may therefore be assumed that the performance-based method will encourage the use of more sustainable materials.

The direct costs can be reduced not only in terms of savings on manpower and materials, but also – and especially – in terms of incidental costs such as the hire of scaffolding and site costs. Scaffolding hire now represents a growing proportion of the total direct project costs. Longer maintenance cycles enable this type of expenditure to be reduced significantly.

5.2 Indirect cost reductions

Indirect cost reductions can be realized because the long-term performance-based approach enables maintenance contractors to assume responsibility for certain activities which they are better equipped to perform than their clients. In the traditional approach, many activities are duplicated, i.e. conducted by both client and contractor, because information is lost following the once-only tendering process. In the performance-based approach, clear agreements are made with regard to which party is responsible for which activity during the cooperation period.

Process improvements and indirect cost reductions will become particularly apparent following an initial period, once both parties have gained some experience with the new method. The costs of collecting project information, consultation, inventories, inspections and the production of alternative maintenance scenarios are likely to be high. Due to the continuity of the performance-based partnering agreement, however, maintenance contractors can improve their internal business processes, with more efficient logistical deployment of manpower and equipment, and more efficient purchasing of materials.

6. Direct and indirect cost savings projects

6.1 Comparison of indirect costs

Table 2 shows the differences in indirect and direct costs of the projects between the performance-based approach and the traditional approach in percentages. In every project, the total indirect costs are lower in the performance-based approach than in the traditional working method (18-72%). However, the costs of the initial processes in half of the projects are higher in the performance-based approach than in the traditional approach. Further analysis reveals that the each of the subsequent part-phases within the initial process will vary, and may be more expensive or less expensive. Only the ‘Evaluation and After-care’ phase is more expensive in every project when using the performance-based approach.

The fact that the indirect costs of the performance-based approach are lower overall than those of the traditional approach is entirely due to the reduction achieved in the subsequent phases, being in excess of 26%. The phases ‘Specification, Selection and Contracting’ and ‘Work and Supervision’ become markedly less expensive. The ‘Evaluation and After-care’ phase is markedly more expensive in every case when the performance-based approach is adopted.

It may be seen that the performance-based approach will offer the lowest indirect costs to the client. It offers not only a financial advantage in the subsequent processes, but in the initial process too. The indirect costs to the contractor are also lower in the performance-based approach than in the traditional working method, although the savings are somewhat more modest than those enjoyed by the client. The initial process is more expensive within the performance-based approach. That this method is nevertheless less expensive overall for the contractor is due to the cost reductions in the subsequent processes. The situation in complex cased is almost similar to that in the simple cases.

6.2 Comparison of direct costs

In all cases, the direct costs of the performance-based approach are lower, or at worst the same, as in the traditional approach. However, it should be noted that the maintenance scenarios used were based on several assumptions. Clients and contractors believe that the maintenance intervals could be extended if working with the performance-based system, from six to seven years, for example. Accordingly, in a maintenance scenario of thirty years, there would be only four maintenance intervals rather than the current five. This view is based on experiences with performance-based partnering and the results of performance measurements. The performance of adequate preventative maintenance would also obviate the need for building components to be replaced. This potentially large financial advantage was incorporated into only a few of the case studies.

In a traditional multiple, competitive tendering process a lower price may be the outcome compared to price, based upon agreed unit prices in performance-based partnering. This is especially the case in very competitive markets, like the Dutch maintenance market at present.

However, on the long term and under changing market circumstances, clients and contractors believe that this will have no effect.

Cost savings of indirect costs may be unimportant compared to the direct costs. Our findings prove not. The indirect costs are in the proportion of 12 to 25% in the traditional approach and 4 to 20% in the performance-based approach. We think that proportion is very significant.

Table 2: Cost savings performance-based approach compared to the traditional approach

Project		**Dwellings**	**Indirect costs**									**Direct costs**
			Client			**Contractor**			**Total**			
			Ini	**Seq**	**Tot**	**Ini**	**Seq**	**Tot**	**Ini**	**Seq**	**Tot**	
Koekoekstraat	S	28	-21	-65	-60	+33	-55	-44	+ 4	-60	-53	-25
Vrijmoedhof	S	92	-16	-37	-32	+27	-17	- 7	+ 5	-26	-19	0
Guldenslag	S	111	+17	-56	-36	+32	-48	-27	+26	-51	-30	-10
Platte Daken	S	178	-61	-64	-63	+13	-20	-12	-28	-44	-40	0
Geroflat	S	360	-40	-56	-52	+18	-13	- 6	-15	-38	-32	-19
Lelie	S	68	-22	-72	-62	+30	-27	-15	+ 4	-49	-38	-14
Eksterstraat	C	103	-46	-72	-65	+18	-49	-28	- 7	-59	-44	-13
Celebesstraat	C	28	-24	-47	-36	-25	-29	-27	-24	-27	-31	- 8
Eekhoornweide	C	45	-33	-40	-37	+18	-23	+ 2	- 5	-33	-18	- 9
Molenhoek	C	27	-41	-92	-82	+24	-92	-70	+11	-92	-72	- 5

S = simple project, C= complex project. Ini = initial process, Seq = Subsequent process.

7. Business operations

The performance-based partnering approach has consequences for all aspects of business operations, organizational structure, organizational culture, the necessary knowledge and expertise, information flows, and the availability and use of methods and instruments on the part of both client and contractor. The costs and returns of these factors are difficult to quantify.

7.1 Client's business operations

The client's initial selection of contractors is likely to cost more time in the performance-based approach than in the traditional method. The selection will not be for each individual project, but the client will divide the projects among a number of pre-selected contractors. Standard activities and unit prices can be agreed between the client and the selected contractors, to be established by means of a framework contract (which will also cover other project-related matters).

Prior to the initial phase of the first project (or projects) the client and contractors will be required to devote considerable time to seeking out the most appropriate partnership form(s), agreeing unit prices and normative performance indicators, and drawing up the relevant framework contracts. However, these activities are also part of the traditional working method, albeit under different names. Like selection, the evaluation of contractors and the assessment of customer satisfaction will also take place outside the confines of individual projects, although project-related aspects will also be taken into account in the evaluation.

7.2 Contractor's business operations

Within the performance-based approach, the contractor acts as a consultant to the client. This entails new activities, such as providing advice on maintenance strategies, the production of maintenance scenarios, performance measurement and conducting customer satisfaction surveys. These activities demand a different type of knowledge and expertise on the part of the contractor. The maintenance contractors must be able to achieve a sufficient level of turnover under performance-based partnering agreements in order to be able to perform these 'advisory tasks' in a satisfactory manner.

Within the performance-based partnering approach, new projects will often require the client to conduct a single-phase tendering procedure. This greatly increases the likelihood of the offer being accepted, compared to the competitive tender procedure common in the traditional approach. This enhanced likelihood of acceptance represents a marked reduction in operating costs for the contractor. Moreover, because maintenance activities are assigned to the contractor for a long period (covering a number of maintenance intervals), it is no longer necessary to re-bid for each period. This continuity will result in lower indirect project-related costs throughout the subsequent process.

8. Conclusions

Long-term, performance-based partnering offers many advantages compared to the traditional tendering approach. One of the main benefits is that long-term performance-based cooperation reduces both direct and indirect costs. The essential preconditions are long-term involvement and freedom in the maintenance design and process, giving opportunities for product and maintenance process improvements and innovations.

Our research findings show that indirect costs are lower in a performance-based approach than in a traditional working method. The fact that the indirect costs of the performance-based approach are lower overall than those of the traditional approach is entirely due to the reduction achieved in the subsequent phases. The performance-based approach offers the lowest indirect costs to the client. It offers not only a financial advantage in the subsequent processes, but in the initial process too. The indirect costs to the contractor are also lower in the performance-based approach than in the traditional working method, although the savings are somewhat more modest than those enjoyed by the client.

A long-term performance-based cooperation form offers a better guarantee of actually achieving higher performance and lower direct costs. In practise maintenance intervals are extended if working with the performance-based system, from six to seven years.

Most benefits of a performance-based partnering approach are not easy to quantify. For contractors a performance-based approach meaning a single-phase tendering procedure offers great benefits. An enhanced likelihood of acceptance represents a marked reduction in operating costs for the contractor.

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Modelling of Competitive Construction Cost Estimate

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Abstract

Construction cost estimating, control and analyze are the main tools in construction project management. Construction cost estimating makes influence on the final project effectiveness. Construction cost estimating goals, methods and accuracy differ according to the stage of construction project. Systematically arranging construction preparation, contractor will know how to reduce construction direct cost before other competition. That is the main strategy of contractors that allows increasing competitiveness.

Keywords – Project management, construction preparation, cost estimation.

1. Introduction

Within the process of economy expansion in Lithuania construction market and cooperation relations among market members are developing. The influence on cooperation relations among market members of construction market is made by free market economy and law acts, which regulate construction business in Lithuania. The mode of behaviour and activity of construction market members has completely changed. Engineering, organizational, economical and management mode of activity of contractors has transformed essentially within the process of economy expansion. Under the influence of changing construction market adaptation of activity of construction companies is taking place. Under the current circumstances a fierce competition among contractors is prevailing. Thus, a strategy of increase of a contractor's competitiveness is the application of the method of construction project management in a company. The method of construction project management has been widely employed in the USA, Western Europe and other countries for almost 30 years [1]. The International Project Management Association (IPMA) has revealed that project management enables to shorten the period of project implementation approximately by 20-30 per cent and decrease investment value by 10-15 per cent. The mentioned method has been employed in Lithuania just recently.

The problems of economy efficiency are relevant in every stage of project management. Estimates of construction costs are of great importance too [2]. To be more exact, the estimating of construction cost as well as control, correction and analysis of efficiency constitute a major part of construction project management.

Estimates of construction costs as documents integrate knowledge from different science fields such as system engineering, technologies, economy, mathematics, computer science and law. The estimating of construction costs as well as control, correction and analysis determine the final efficiency of a project. Therefore, estimates of construction costs are a new and relevant object of integrated research in Lithuania.

The aim of the research is to prepare techniques for contractors to enable them to design competitive estimates of construction costs.

2. The Place of Estimates of Construction Costs in Project Management System

Construction project implementation system is divided into stages [1]. Constructions costs are estimated in all stages of construction project: business plan, schematic design, detail design, constructs proposal, construction preparation and completion of works. In the stage of need analyses, tasks, restrictions and potential ways of project implementation are formulated. In the process of carrying out the financial analysis on the basis of consolidated rates or analogical construction projects costs considering the selection of construction plots variants are estimated. The aim of such calculations is to estimate demand in investments and financing possibilities.

Pre-project stage deal with juridical issues of project implementation as well as such questions as if is it purposeful to purchase or rent land plots as well as conditions raised for license to perform construction works are taken into consideration. In this stage principal technical decisions are provided in details, optimal project variants are selected, estimate of project costs on the basis of consolidated rates is presented and period of construction works is estimated.

Within the process of detail designing technical project of a building is prepared. Detailed estimate constitutes a part of this project. Upon conclusion of the technical project and estimate a competition for performance of construction works is arranged. The contractor, who wins the competition carries out the construction preparation, designs a project of implementation of works and performs construction works. Within the process of building transfer for usage, the discovered drawbacks of construction works are being removed. Then, the building is used; its maintenance, repair and reconstruction are carried out.

The main purpose of estimates is to estimate construction costs, value and total investment value. Estimate is the most relevant document as a means of assistance for client to adopt appropriate decisions. As for contractor, estimate has essential importance in estimating costs, controlling and analysis of efficiency.

The block scheme of construction cost estimates is provided in Figure 1. The following constructions cost estimates are estimated in the European countries [3].

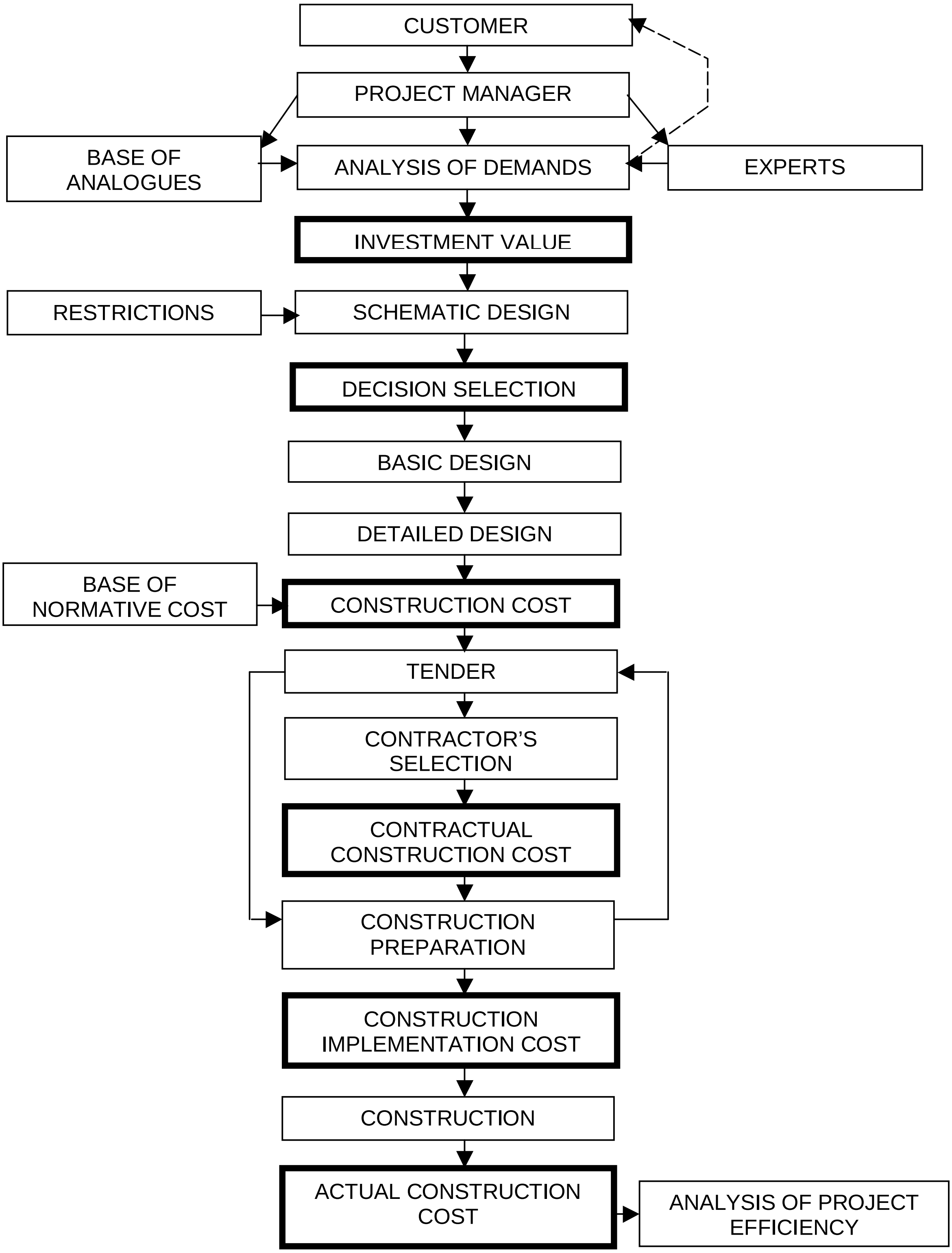

Figure 1: The place of cost estimates in construction project

Classification of costs, standard database and techniques of estimating construction cost differ in various countries [2]. Aim and techniques of estimating construction cost as well as precision of the estimated price differ according to the stage of construction project implementation.

Defining initial construction cost. Initial construction cost is defined in the stage of business plan. The main purpose is estimating cost of investment and making owner's decisions. The price reveals concept of the project. Its precision amounts 30 percent. Consolidated rates or analogical projects are used in estimating construction costs in this stage.

Construction costs estimate in the schematic design stage. It is used in comparison of principal technical decisions of construction project.

Construction costs estimate in the process of public tender for purchases. Public tender for purchases is organized on the client's initiative aiming to choose a contractor (prime contractor) for implementation of construction works. Upon choosing a contractor the client estimates the costs and proposals submitted by experts. For example, researches were done to estimate distribution order of construction bid price for homogeneous 39 objects group (Figure 2) [4]. The results of research can be used by future costumer's to estimate construction bid price for analogue objects and strategy to select contractor.

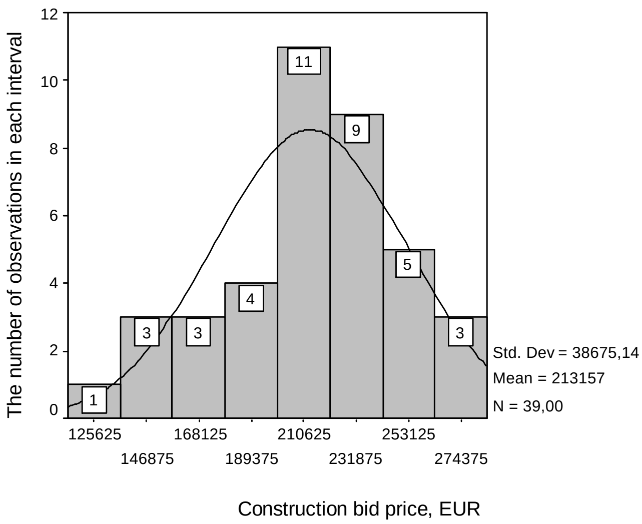

Figure 2: Histogram of construction bid price values

Estimate of construction implementation costs. It has to be prepared in the process of construction preparation (Figure 4). Within this process a contractor may prepare alternative project decisions on construction processes, optimize and integrate them into calculation of estimate of construction costs [3]. It allows a contractor to decrease construction cost up to 30 percent, and shorten the period of construction works by 50 percent [5]. Optimization of project decisions of construction processes increases competitiveness of contractor's proposal during the tender.

Actual estimate of construction costs. Within the process of building transfer for usage the actual construction costs shall be calculated. It is necessary for implementing analysis and defining the ultimate efficiency of the construction project. Actual estimate of construction costs reveals implanting level of rational decisions, effectiveness of the decisions and their reliability. According to the Figure 3, the variation limits of construction costs were calculated for the same type, homogeneous 39 objects group. It allows that contractor can forecast the means for cost reduction.

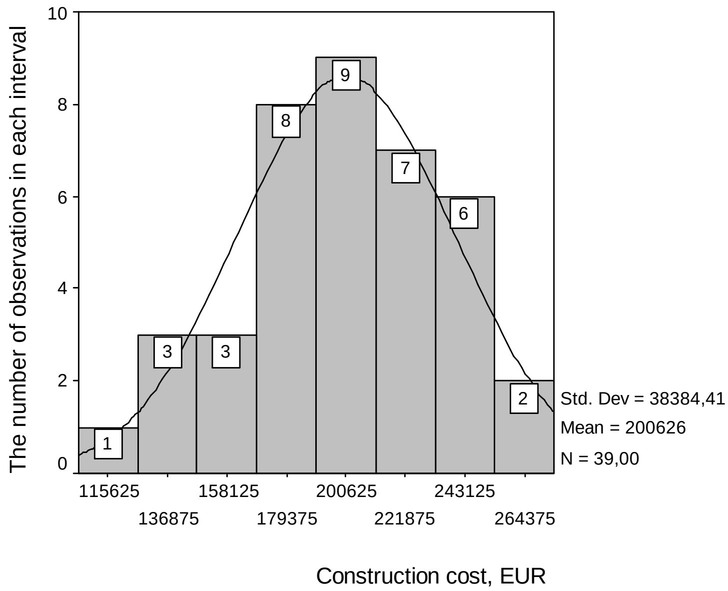

Figure 3: Histogram of construction cost values

Classification of an estimate into one of these types depends on the available information, the extent of effort dedicated to preparation, and the use for the estimate. The classification of an estimate into one of these categories is an expression of the relative confidence in the accuracy of the estimate.

3. Construction Cost Estimation in Lithuania

The concept of construction project management occurred only 4-5 years ago in Lithuania. Participants of construction business perceive this concept deeper and use the methodology of construction project management in their activity, which requires transformation of management system of construction companies.

As cooperation ways among construction participants are changing in Lithuania, the attitude towards the importance, place and drawing up of estimates changes as well. The methods of drawing up estimates in Lithuania are presented in the Table 1 below.

Table 1: Drawing up estimates of constructions in Lithuania.

	Stages of construction project			
	Stage of possibilities	Pre-project stage	Projecting	Construction
Estimate types	Estimate drawn up according to comparable economical indexes	Estimate drawn up according to large-scale indexes	Estimate drawn up according to normative valuation	Actual estimate
Data of drawing up estimates	Preliminary known volume of the building and characteristics, area of construction, engineering networks	Known main indexes and quantities of a building – foundations, framework, walls, roof, finish and others.	Known precise quantities of works of a building according to the project	Known precise quantities of works, costs and price
Methods of drawing up estimates	Eur/m^3, Eur/m^2 Eur/m´	Drawn-up according to large-scale valuations of work groups Eur/m^3, Eur/m^2, Eur/m	Drawn-up according to normative valuations for each piece of work or process	Drawn-up according to the actual costs by specifying prices and quantities of works

The estimate according to the comparable economical indexes is drawn up within the period of defining customer's aims and needs. The previously mentioned estimate is drawn up having such characteristics of a building as total area, volume of a building and the length of outdoor engineering networks. In this stage of the constructional project a customer estimates the value of future investments.

Having projected the construction systems of a building (foundations, walls, roof etc), the estimate according to the large-scale normative is drawn-up. The aim of drawing up such an estimate is to present comparable indexes of the project and indexes of the project parts to the customer, according which optimal project decisions are selected. Herewith the previously drawn-up estimate is specified.

Having drawn up the detailed project, the customer announces a tender for performing of construction works. Furthermore, an estimate according to normative valuations is drawn up on the customer's initiative. The basis of drawing up of such an estimate is the normative prices of construction works and quantities according to the detailed project.

The contractor upon receipt of participating in the tender calculates the price of the construction offer. For that purpose quantities of construction works according to the detailed project are used or they are recalculated. In this estimate the contractor evaluates construction implementation cost, additional costs and profit.

Having completed construction works, actual construction costs are calculated and estimate of construction are drawn up. This estimate reveals specified quantities of construction works, prices and additional works occurred in the construction processes implementation.

Currently the following contractors' decisions prevail in Lithuania, while participating in tender, contractors decrease the offer price deliberately and increase their risk to the maximum. Having won the tender such contractors frequently experience losses and problems of liquidity.

Good construction engineering preparation has great importance on assuring contractors' competitive ability and profitability (Figure 4) and requires adequate costs of engineering works. Thus, such works in Lithuania are not performed in full. Due to this reason substantiation of tender prices is insufficient an unprofitable projects and loss-making activities of some construction companies develop subsequently. Moreover, construction companies do not use estimates as an instrument of regulation, analysis and management of costs.

4. Construction Cost Estimation and Modelling

Currently the tender method based on the lowest price is employed in Lithuania, i.e. the tender is won by that contractor who offers the lowest bid, but not less than 15 % from the average price of all the competitors participating in the tender. In such way a limitation occurs, which prevents a contractor to win the tender having offered the lowest price for the performance of construction works. While using the tender method based on the lowest price a customer confronts a greater risk that a contractor, having won the tender by the lowest bid price, will not be able to perform construction works according to the price referred in the contract. [6]. Therefore, there are two possibilities aiming to win the tender:

1. Offer the lowest but reasonable price in the tender;

2. Aim to define the price close to the price, which is 15% lower from the average price of all the competitors participating in the tender.

The contractor, aiming to offer the lowest but reasonable price in the tender, should be aware of the price reducing possibilities and reserves, which depend on the type and quantity of construction works. This may be implemented in construction engineering preparation stage. Block scheme of construction preparation is provided in the Figure 4. Construction preparation is a separate system, closely related with other stages of project management.

In Lithuania the concept of construction preparation under the conditions in market economy has gained a new meaning. Therefore new construction preparation works such as preparation for participation in tenders, projecting of competitive construction estimates, risk assessment etc. emerged. The indicated work of construction preparation requires specialists of high qualification as well as provision with methodical material. In this stage optimization of project decisions of construction processes is of great importance and their further implementation within the period of construction works (Figure 4). It enables to reduce construction costs and receive more profit. Optimization of project decisions of construction processes is made algorithmic and is implemented by the means of a PC.

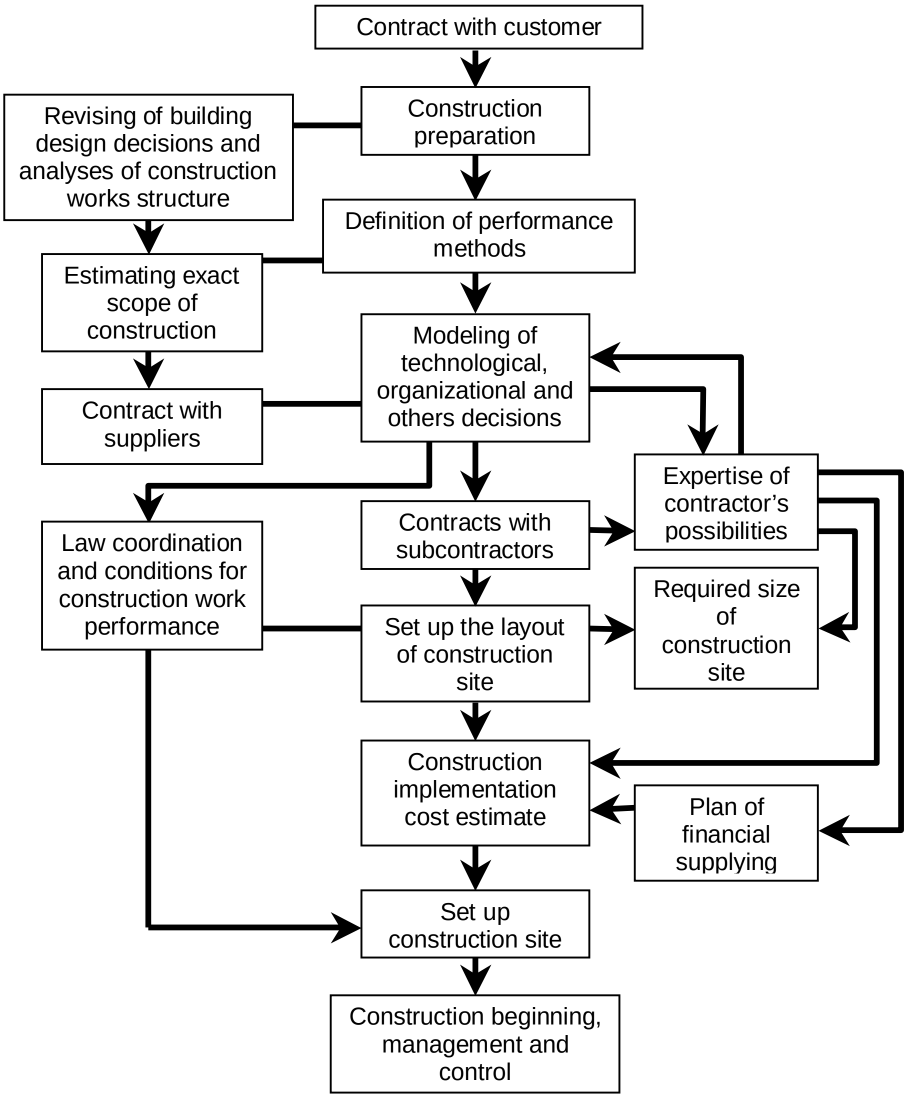

Figure 4: Scheme of construction preparation system

Within the processes of optimization and selection of rational decisions general investments into constructions in different stages of construction project implementation may be reduced (Figure 1). However, a contractor defines the possibilities of direct costs reduction and this is performed within the process of construction preparation (Figure 4). In this stage alternatives of constructions processes implementation are investigated, evaluated and optimal decisions defined which, afterwards, are implemented. For this purpose a complex construction process is divided into simple processes, possible ways, i.e. alternatives, of implementation of the mentioned simple processes are foreseen, then the alternatives are evaluated and rational decisions are selected. In order to adopt optimal decisions mathematical models of construction processes may be projected. Research methods of operations, correlation analysis and other methods are employed in this stage. Optimal decisions of construction processes are integrated into the documentation of construction implementation. The documentation includes time and finance schedules of construction works implementation, estimates, schedules of additional project works, subcontractors' works, materials, demand for labour force and machines as well as schedules of provision and control of construction processes.

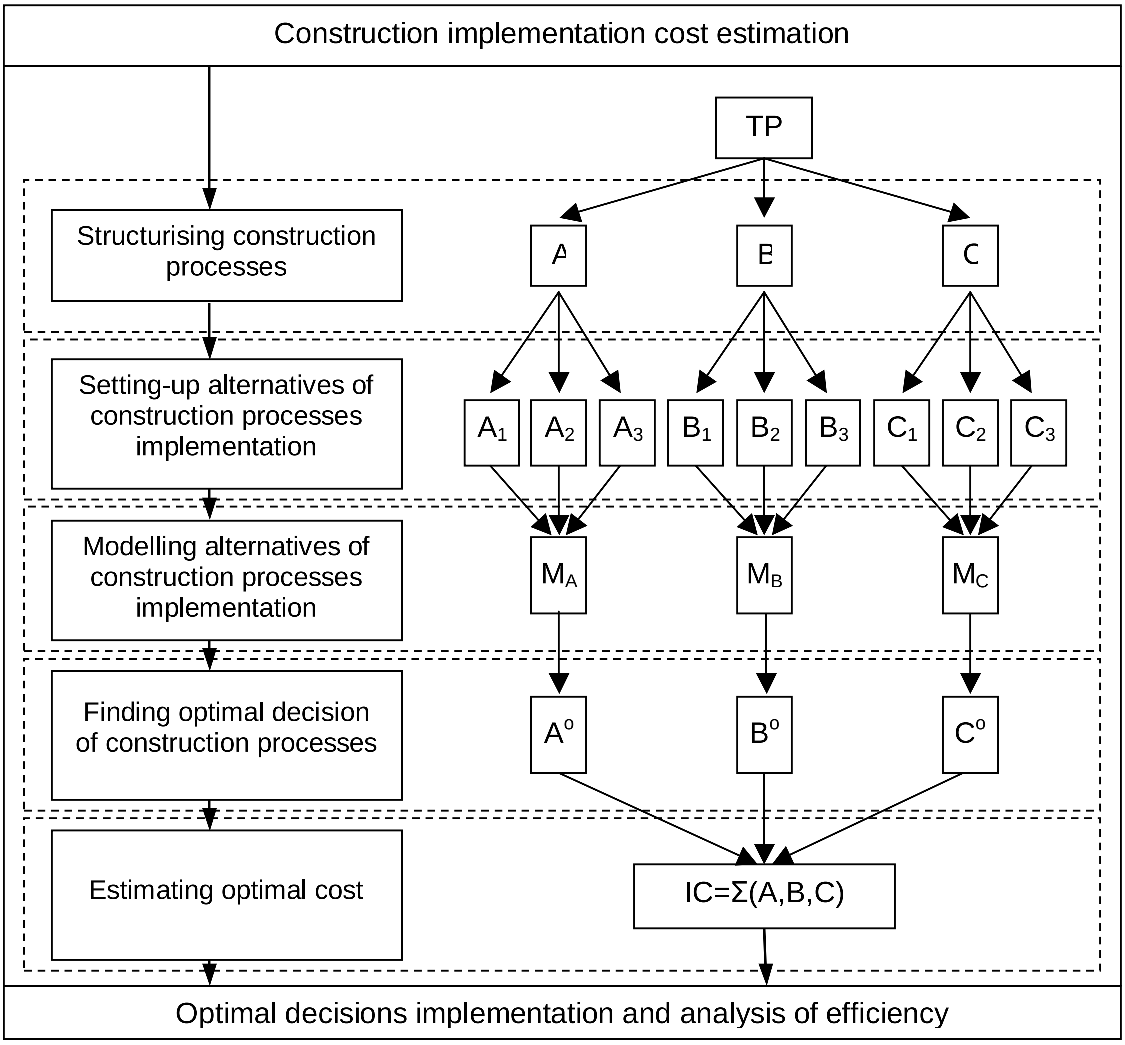

Figure 5: Block scheme of work implementation estimate

Algorithm of optimal construction decisions preparation and drawing up of work implementation estimate is shown in Figure 5. While drawing up a work implementation estimate, the terms and restrictions are followed, which are presented in the detailed project and construction standards. This is evaluated by projecting alternatives of potential decisions of construction processes. The following mathematical optimization methods are employed for evaluation and optimization of construction processes project decisions: game theory, correlation and regress analysis, mathematical programming, theory of massive service [7].

The researches carried out by Kaunas University of Technology reveal that optimal decisions of construction processes may be obtained by applying properly selected methods of optimization. Having realized the decisions practically the contractors may reduce construction costs up to 30% whereas the period of construction works may be shortened up to 50% [8], [9], [5], [10], [11], [7]. Currently software is being developed which will enable to integrate optimal construction processes project decisions into estimates.

5. Conclusions

The concept of construction project management in Lithuania occurred only 4-5 years ago. Participants of construction business perceive this concept deeper and use the methodology of construction project management in their activity, which requires transformation of management system of constructional companies. Good construction engineering preparation has great importance on assuring contractors' competitive ability and profitability. Construction estimates are a very important document of construction engineering preparation. However, Lithuanian construction companies still do not use estimates as an instrument of regulation, analysis and management of costs. The researches carried out by Kaunas University of Technology reveal that effective decisions of construction processes may be obtained by applying properly selected methods of optimization within the period of construction engineering preparation. Having realized the decisions practically the contractors may reduce construction costs up to 30% whereas the period of construction works may be shortened up to 50%. The mathematical optimization methods and system engineering methods are employed for preparation, evaluation and optimization of construction processes project decisions. Currently special software is being developed for integration of optimal project decisions of construction processes into estimates.

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Construction Risk Identification

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Abstract

The management of risks in projects is a growing area of concern in the construction industry. Both the identification and analysis phases of the risk management process are considered the most important, for they can have a big impact on the accuracy of the risk assessment exercise. Currently it is assumed that construction project managers rely largely on experience to identify projects risks. These decisions, influenced by individual perception and attitudes, are made primarily under conditions of uncertainty. How individuals respond to risky or uncertain situations therefore requires an understanding of how individuals intuitively assess the situation they perceive, before expressing a response. The ProRIde project interviewed fifty-one construction project managers using Active Information Search (AIS) as a data collection method and cognitive mapping as a data-capturing tool. Our results suggest that the role of experience in the risk identification process is much less significant than is commonly assumed to be. By contrast, level of education and style of enquiry do play a significant role in risk identification performance. These findings suggest the potential for a more thorough approach to risk identification.

Keywords: project risk management, risk identification, active information search and cognitive mapping.

1. Introduction

Risk management has become an important area of interest in the field of construction project management over the past decade. Interest in the management of risk has increased as competition between firms, and as the size and complexity of project has grown. This has led to the development of best practice standards, tools and techniques. Both the risk identification and risk analysis phases of the risk management process (RMP) are generally considered the most important as these can have the biggest impact on the precision of the risk assessment [1-3]. While the analysis process and its tools and techniques are well developed, such analysis is dependent on risk being accurately identified in the first instance. However, compared with the analysis phase, the process of risk identification is poorly understood and the tools and techniques are less developed. The aim of the ProRIde research funded by the UK Engineering and Physical Sciences Research Council (award GR/N51452/01) is to provide a better understanding of the project risk identification process. Thus we focus our research on the ways in which construction project managers identify risks; our aim is to provide the basis for a more rigorous approach to the identification phase of project risk management.

2. Project Risk Management: An Overview

Interest in project risk management has increased as the size and complexity of projects has grown and as competition between businesses intensifies. The rapidly changing context and its influence on the way projects develop has made the RMP an ever more important challenge. Numerous best practice standards such as *A Guide to the Project Management Body of Knowledge* (PMBoK® Guide)[4], *Project Risk Analysis and Management Guide* (PRAM) [5], *RAMP: Risk Analysis and Management for Projects* guide [6] and the British Standards Institution guides [7; 8], as well as specialist tools and techniques have been developed focussing on a more effective RMP. These standards share a basic conception of the RMP (Figure 1). This generic model consists of four basic sub-processes located in the context of clearly defined project objectives, which are iteratively looped through the project lifecycle: identify and classify the risks, analyse the risks, respond to the risks and monitor the risks. There is also a growing body of research on the process as a whole, with increasing advocacy of risk management maturity models [9].

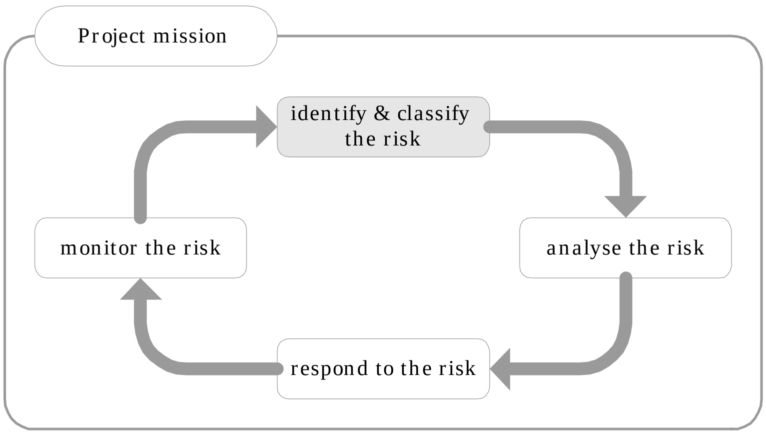

Figure 1: A generic model of the risk management sub-processes [10]

The identification phase, where the question of what might happen is addressed, has been the subject of much less research compared with the analysis phase. The most recent exceptions include research on the effectiveness of risk identification tools at group level [1] and the influences on risk identification and assessment in construction design management [11]. However, risk identification remains a poorly understood process and its tools and techniques are less developed compared to those used in the risk analysis phase [12; 13]. The focus of the literature is on the tools and techniques used for assisting in risk identification, such as risk registers, risk breakdown structures (RBS) and brainstorming. The widely used risk register is a list of all the risks that have been previously identified; its development is typically ad-hoc. For this to be of practical use, the register has to be filtered for a particular project under scrutiny and the results prioritised. However, it is not clear how this is done and how reliable the results are [14]. There appears to be a complete lack of connection with the literature on knowledge management as a tool for capturing organisational learning from projects [15]. Gaining such understanding requires the systematic analysis of data for a large number of projects, but such data sets are difficult to acquire – Dalton [16] reports on one attempt to fill this gap. RBS provide a hierarchical structure of potential risk sources [17] from which a list of risks can be drawn through a brainstorming session. Brainstorming [18] is project specific and requires a group of experienced practitioners to creatively consider possible risk sources. The list is then more analytically considered and key risks identified. The difficulties with brainstorming include the selection of the appropriate experts and their number, bringing these experts together frequently enough to be of use to a dynamic project lifecycle, and the avoidance of “groupthink” dynamics.

In construction projects there are some standard risk areas that need to be considered and assessed, but each new project also brings specific project related risks, which need to be identified. The difficulty is the lack of accurate systems for identifying risks in a construction project. The studies that have been carried out over the past decade on the use of risk management practices in construction and other industries [1; 2; 19-23] indicate that over this time: checklists, brainstorming and interview sessions have been the most commonly used risk identification tools; other techniques are rarely used due to lack of knowledge and doubts about their applicability in the construction industry; there is limited progress on the wider application of tools and techniques; there is concern that in practice the distinction between the risk management process phases is blurred and existing tools are not sufficient. Research currently assumes that the construction industry relies heavily on historical data and the judgement of key actors involved in the project to identify risks. For instance, Chapman [11], and Al-Tabtabai and Diekmann [24] state that the identification of risks relies on the individual judgement and insight of the various actors involved in a project, which is dependent on their knowledge, professional training, role, level of responsibility and length of exposure to the construction industry. The premise of both research and practice in project risk management is that experience is *the* key to risk identification.

3. ProRIde: the Method

Project risk identification is part of the more general problem of judgement under uncertainty [25]. To address this problem in a project context, we draw upon a critique of the predominant perspectives in this area –*Expected Utility Theory* [26]. Here the decision-maker rationally evaluates the probabilities against a final asset position before choosing a course of action. However, this theory has been criticised for its assumption that rationality is possible under such conditions, because evidence has been found that decision-makers use flawed heuristics in decision-making, which are subject to systematic biases [27; 28]. Within this perspective, Kahneman and Tversky [29] proposed their *prospect theory*, a system in which decision-makers assign values to gains and losses rather than to final assets and to decision weights rather than to probabilities. This produces the distinctive s-curve value function of the theory. While there have been important debates within the heuristics and biases literature [30], this probabilistic approach to decision-making has been widely accepted. However, the heuristic and biases critique of expected utility theory has been criticised on methodological grounds due to the artificial nature of the decision problems [31]. In essence, decision-makers are presented with well-defined problems with all required probability distributions available. In practice, an active information search is required by decision-makers to tease out the nature of the problem situation and assign the appropriate decision weights to the data. This naturalistic approach is much closer to the sort of situation facing project risk decision-makers than those of perfect information envisaged by expected utility theory and bounded rationality envisioned by prospect theory. The research methodology used in this research is based on active information search (AIS).

AIS was developed to study judgement and decision-making in naturalistic tasks. These are ill structured problems of information rich domains, where causal relations and attributions and the decision-makers' control belief are relevant [31]. At its core AIS is a process tracing technique of information search and collection, carried out in the context of an interview where the interviewee is presented with a scenario of a problem. After the review of the scenario the interviewee asks the facilitator questions in order to obtain information. These questions are recorded and answers are provided in printed form. Huber's model of how individuals reach a decision in a naturalistic situation assumes that the decision maker constructs a simple mental representation of the situation and alternatives, which can change in the course of the decision process. This research utilises the developments in these techniques proposed by Ranyard et al. [32] and Williamson and Ranyard [33; 34].

These developments do not, however fully address the issue of the recording of the cognitive processes revealed by the AIS technique. For this reason, we turned to cognitive mapping as a data recording and analysis method. Cognitive mapping [35] is an interactive decision support tool used to analyse the complex or messy processes through which decisions emerge. A cognitive map is a graphical model that structures the way and individual makes sense of their experiences. The map is represented by concepts (distinct phrases) and links between concepts, thus creating a system of concepts that communicate the nature of a problem. Although cognitive mapping has already been used in the project risk management area [36] [37], its application to the problem of project risk identification and its combination with an active information search methodology is novel.

The ProRIde AIS interview procedure [38] lasted between one and a half and two hours and was structured in three stages: 1) introduction and warm-up; 2) AIS/scenario exercise; 3) summary. The introduction informed the interviewee of the aim of the project, the structure of the interview process and what was expected of the interviewee. The aim was to clarify the exercise to the interviewee, but at the same time information was kept to a minimum so as not to influence the outcome of the AIS exercise. The warm-up exercise aimed to clarify the dynamics of the main exercise (AIS), such as thinking aloud and using questions and answers. The aim of the summary was to obtain a retrospective view of the risks identified.

The aim of the AIS exercise was to produce a response from the practicing managers that would match, as much as possible, their natural behaviour. The scenario, based on a real construction project, was developed by the research team in collaboration with the project manager of the real project. The scenario described a building project under a Design and Build contract that was currently in progress; participants were given limited information about its location, team, cost, client and project status with a focus on schedule and budget risks. The limited information meant that the potential of the scenario to shape the interviewees' responses was kept to a minimum and would compel the interviewee to request additional information from the facilitator. This process needed to occur in order for the AIS method to work. Each interviewee was asked to assume that they were part of the project team and that they had to take over the project at short notice. Each interviewee then went through the AIS process described above with the aim of identifying the main risks in the project.

4. ProRIde : Initial data analysis

Potential interviewees were initially identified by our four collaborating UK construction firms. These firms comprised: two large international construction firms, one large UK national construction firm, and one medium-sized London-based construction firm. The criteria for the selection of interviewees included individuals with a minimum of two years experience in a construction management position and who could potentially take over a project at short notice. As the interviews progressed, the four firms provided our research team with a list of twelve-to-twenty potential participants. To select the interviewees, our research team used a judgment sampling based on professional role. We interviewed fifty-one (4 female, 47 male) practicing construction project managers from the four collaborating firms. The first five interviews constituted a face validity exercise for both the risk propensity questionnaire and AIS approach. Two interviews could not be conducted properly due to time constraints; we have excluded this data from the analysis. We used for this analysis the data from 45 of our interviews. Although our sample is not random, we believe that it is reasonable to suggest that our findings offer fairly typical results for middle-level managers in the UK construction industry. We have no reason to believe that it is systematically biased in any particular way; we believe that the results can be generalized to other project managers on asset acquisition projects.

4.1 Active Information Search Analysis

Both the scenario and summary stages were tape-recorded; from this, transcripts were generated. The verbal reports (sequential transcripts) contain data on the lines of reasoning and type of information searched for and used during the scenario exercise. Due to the volume of data gathered (15-20 pages per transcript) we recognized that we needed to do more than analyse the content. Therefore, we used Decision Explorer™ (cognitive mapping software) to graphically represent the AIS data. This type of graphical representation can still be considered a cognitive map because it represents "*people in relation to their information environment*" [39]. For the purpose of clarity, we will refer to these as *information search maps.*

Our maps were built by transcribing the information directly into Decision Explorer™. Starting at the beginning of the tape, we entered sequentially numbered concepts (distinct phrases) into Decision Explorer and linked these to represent a chronological relation (concepts following in time). A concept could be a question or statement from the interviewee or an answer from the facilitator. The sequence of concepts and links was broken when a new question was asked about a new or different theme; the new concept then marked the start of a new line of inquiry and reasoning. During this stage, we developed a coding framework for three distinct variables: concept variable, process variable and outcome variable. The concept variable was coded as answers (facilitator's input), questions and statements. The process variable indicates the approach taken to search and collect information; this could be in a *linear* or *feedback* mode. A linear style approach was evident when the interviewees asked a series of single independent questions without follow-up. A feedback-style approach was evident when the interviewees asked a series of related questions in an investigative manner. The outcome variable is the risks identified by the interviewees. To improve coding reliability, two coders independently examined the information search maps. The comparison between coded maps indicated a high percentage of agreement (.99) between the two coders.

Each coded map contained between 200 and 600 concepts. To help manage the data, we used the Decision Explorer™ cluster analysis option, in which individual information search maps were segmented into groups of concepts (called clusters). Concepts were grouped based on the strength of linkage. Each cluster describes the sequence and style of information search an interviewee went through during a particular theme of the scenario. In this sense, each cluster describes a specific theme; and each is given a title to capture its contents.

In order for the *information search maps* to be compared, it was necessary to summarise them further. Therefore, a *summary information search map* was created for each interviewee using VISIO™. These summary maps contain data about the information that was sought (cluster titles), the sequence of the information search (arrows), the number of questions asked per theme (cluster size and number in parenthesis), the style of information search used (feedback, linear), the approaches used (assessment, self orientation, further action), the risks identified, and feedback loops (dashed links). Figure 2 provides an example of an individual summary information search map.

To read the summary information search map start at the bottom left side and work your way through by following the arrows. We can see that this interviewee searched for information related to the schedule and sectional handover in the first instance (cluster 1). This information was sought using a feedback style approach (arrowed circles), where 3 questions were asked (number in parenthesis). A feedback style was the main style of information search used (more than 50% of clusters are feedback); this led to the identification of three risks (coded as b,c,d). A linear style approach was used to cover permit aspects and one risk (coded as a) was identified through this approach. By reading the cluster titles we can see that the scope of information search was limited to very particular aspects of the project, such as things on the ground and design. Self-orientation was a common strategy used to navigate through the information acquired during the task (clusters 7,15,16,17,18,19,21). In total four risks were identified with limited scope and impact.

The project manager who managed the real-life construction project on which the scenario was based is a member of the research team. We were able, therefore, to benefit from his detailed knowledge of the scenario's background to assess the potential impact that each of the risks identified by the interviewees would have on the scenario project. In other words, we benefited from hindsight knowledge in establishing the potential impact of each risk event identified by the interviewees. This procedure allowed a risk identification performance (RIP) measure to be developed. All identified risks were entered into a matrix and rated individually on a 1 (very low) to 5 (very high) impact scale. The rated matrix was independently reviewed for consistency. The total number of risks identified by each interviewee weighted by their potential impact gave us the RIP measure for each interviewee. It is important to note that the RIP measure is not an indication of absolute level of performance, but a relative measure, constrained by our choice of scenario. Due to the use of hindsight, it was not believed to be appropriate to allocate a probability of each risk event occurring to complement the impact. The RIP forms our dependent variable in the subsequent quantitative analysis of the information search maps.

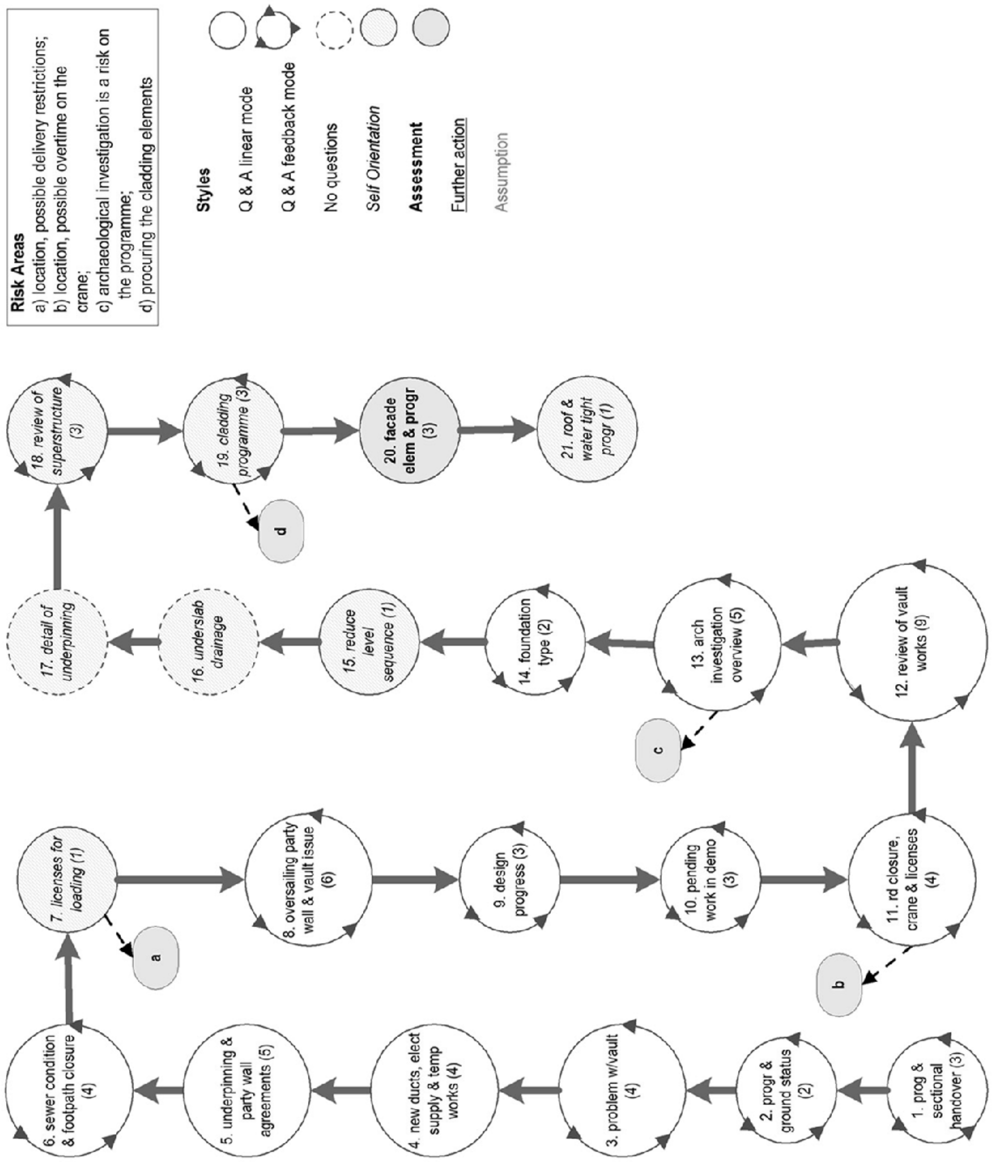

Figure 2: Summary Information Search Map : Feedback style

5. Quantitative results

The individual summary maps provide an overview of the individual risk identification process. These provide data on the information that was sought, the sequence of the information search, and the strategy used for the information search; these also detail which decisions were based on prior experience or training and which were based on information collected during the exercise.

When combined with the results from the risk propensity questionnaire, these provide the data set for the first phase of our research. In this analysis, simple frequency counts and statistical tests are used to explore the patterns in the data set. This quantitative analysis will be complemented by a qualitative analysis of the maps at a later date.

*Table 1: RIP and Demographic Factors (n = 45 * significant at 5% level in all tables)*

Independent Variable	***t- test***	***Spearman's Rho***	***Pearson r, Point-biserial r_{pb} Biserial r_b***
Years in management role			$r = -.186$
Years in current job title			$r = -.198$
Age			$r = -.160$
Risk management training	$t = 1.157$	$\rho = -.212$	$r_{pb} = -.174$
Role	$t= -.819$		$r_{b =} .166$
Education	$t = -2.211$ *	$\rho = .291$ *	$r_{pb} = .320$ *

The risk propensity questionnaire contained a number of standard demographic variables measuring age, experience, education background and level of risk management training which allow us to test these assertions. In our analysis, we treated RIP as the dependent variable and the demographic factors seriatim as the independent variable with a null hypothesis that there is no association between the two. Our review of the data determined the choice of statistical test; the results are summarised in Table 1. As can be seen, we cannot reject the null hypothesis at the 5% level except for the education coded as whether the interviewee was a graduate or not. Experience measured by years in current job title, years in a management role, and age are not significantly associated. Similarly, whether the interviewee has had risk management training or whether his or her role is commercial or production orientated displays no significant association with risk identification performance.

We then took the RIP measure as the dependent variable and style of information search (feedback or linear) as the independent variable with a null hypothesis that there is no association between the two. The results are summarised in table 2. As can be seen we can reject the hypothesis at 5% level for style ratio (ratio of linear/feedback clusters), linear clusters (negatively associated) and feedback cluster (positively associated). This suggests that, as more feedback style of information search was used the higher the RIP score obtained and the inverse for a linear style.

Having identified information search style as significant, we took information search style (feedback and linear) as the dependent variable and experience as the independent variable with a null hypothesis that there is no association. The results are summarised in tables 3 and 4. As can be seen, we cannot reject the null hypothesis at 5% level. This suggests that feedback and linear styles of information search are not significantly associated with experience, measured in number of years in a management role, years in current job title and age.

Next, we took the styles of information search (feedback and linear) and style ratio as the dependent variable and educational attainment (graduate and non-graduate) as the independent variable with a null hypothesis that there is no association. As can be seen in table 5, we cannot reject the null hypothesis at 5% level except for style ratio correlated with educational attainment. Box plots show that style ratio and education were related with more non-graduates tending to have a higher style ratio (more linear style). This suggests that higher educational attainment encourages the use of a feedback style of enquiry in risk identification.

Table 2: RIP and Process Variable

Independent Variable	***Pearson r***
Style ratio	r = -.313 *
Linear clusters	r = -.274 *
Feedback clusters	r = .310 *

Table 3: Feedback style and experience

Independent Variable	***Spearman's Rho***	***Pearson r***
Years in management role	ρ = -.042	r = -.049
Years in job title	ρ = .032	r = -.002
Age	ρ = -.040	r = -.027

Table 4: Linear style and experience

Independent Variable	***Spearman's Rho***	***Pearson r***
Years in management role	ρ = -.241	r = -.232
Years in job title	ρ = -.099	r = -.076
Age	ρ = -.099	r = -.114

Table 5: Information search styles and education

Dependent Variable	***Point-biserial correlation***	***t-test***
Style ratio	r_{pb} = -.268 *	t = 1.1794 *
Feedback cluster	r_{pb} = .052	t = -.344
Linear cluster	r_{pb} = -.117	t = .775

From these data, therefore, we can conclude that there is a significant difference in project RIP between those educated at graduate and non-graduate level; and an association between the style of information search (feedback and linear) and RIP. This finding is both counter-intuitive and interesting. It is counter-intuitive, because it suggests that experience plays no role in project risk identification performance. It is interesting because it suggests that education and training can improve project risk identification performance - years of experience is not subject to managerial intervention to improve performance, but it is possible to train staff. However, the lack of correlation with whether the interviewee had experienced risk management training suggests that existing training programs are not all that they might be. In addition, we find that the process style in which information is gathered also contributes to the RIP. In this case, a feedback style, that is, an iterative investigative approach to information gathering contributes to a better RIP. Again, this suggests the potential for staff training.

6. Conclusions

This paper describes a method for studying how project managers in the construction sector go about identifying risks. The review of the risk management literature showed that the risk identification phase of the risk management process, although one of the most important is poorly understood and that the tools and techniques available are less developed than the ones used in the analysis phase. The review also highlighted the construction industry's concerns about the lack of formal methods to identify risks, as well as their lack of knowledge and doubts about the suitability of the ones available. Understanding how project managers identify risks, that is, the means by which they use their knowledge, expertise, and training, places the inquiry in the area of judgement under uncertainty. The review of the development and critiques of key decision-making theories pointed towards the importance of the use of active information search for teasing out the nature of a problem situation. As a result, the methodology used to study the risk identification process is a conversation-based Active Information Search in combination with cognitive mapping.

Both feedback style and educational background have been highlighted as significant. In sum, the results show that interviewees with a high use of feedback style of information search performed better at identifying high impact risks. Or to put the point the other way round – experience appears to contribute little to effective project risk identification. More detailed analysis of the results suggests that more experienced project managers are more likely to rely upon what might be described as a "checklist mentality", rather than addressing themselves to the details of the particular project they are being asked to manage.

This paper has provided some insights and better understanding into the way that construction project managers identify risk. The method has allowed us to capture the initial thoughts and process. The findings suggest that the preconceptions about the importance of experience of actors in the initial phase of risk identification may well be misguided. We are presently building on these results to do a more qualitative analysis of the ways in which individuals identify project risks, and are also starting to explore the group dynamics of project risk identification.

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Leveraging Shared Knowledge to Achieve Sustainable Competitive Advantage within Construction Alliances

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Abstract

Alliances within construction have increased significantly in number and in the volume of activity that they have undertaken in recent years. Although writers in the field highlight benefits of developing knowledge sharing as a core capability to create and maintain sustained collaboration and sustainable competitive advantage, a majority of the alliances engage in short-term orientated work processes targeting short-term commercial advantages. This paper contextualises this phenomenon within construction alliances and investigates the business logic of developing knowledge sharing as a core capability. The case study conducted reveal that the alliances concentrated on short-term commercial advantages to the detriment of longer term sustainable competitive advantages. Therefore, initiatives taken to improve high quality interactions among alliance participants and thereby sustain inter-firm relationships have not yielded the anticipated benefits.

Keywords: Alliances, knowledge sharing, cognitive-mapping, collaboration, construction industry

1. Introduction

The concept of alliancing is well established in many industries as a means of gaining mutual benefits out of shared competencies and capabilities for firms. Alliances in various forms such as joint ventures, licensing agreements, distribution and supply agreements, research and development partnerships and technical exchanges exist in many industries [1]. Bleek and Ernst [2] points out that on a global scale, the volume of alliance activity has increased at 25% per annum in the first half of 1990's. A later study done by Contractor and Lorange [3] asserted that "the alliance phenomena is here not (*only)* to stay but is set to grow rapidly". In the construction industry too the concept of alliancing has gathered momentum as an appropriate procurement route for large-scale projects [4, 5].

Although there is an increase both in the incidence of alliances as well as in the number of studies been undertaken on various related issues, it is argued that most of the alliance collaborations are short-term focused and alliance partners devote most of their time on resolving issues related to contractual matters, profit sharing and accounting problems [6], which can be to the detriment of sustaining their relationships for more long-term benefits [7]. Alliances in the construction industry, too, are often saddled with this problem of people involved having a short term ‘project based mindset’ [8]. The need to adopt a longer term perspective for alliance development is the main focus of this paper. A case study is presented, which investigate the utility of developing a long term orientated core capability through shared knowledge within joint venture alliances in construction.

2. Literature review

Although Prahalad and Doz [9] have pointed out that alliances create synergies between resources of firms in their progression towards achieving sustainable competitive advantage, many alliances are plagued with high degrees of instability and poor performance. Ingirige and Sexton [10] argue that short-termism is a major problem in alliances generally and in construction in particular. Even during the tenure of construction projects the alliances seek commercial advantages [11] rather than building up relationships through collaboration. This emphasis erodes future benefits arising out of collaboration. Further, this tendency results in activities being targeted at controlling the relationships rather than nurturing them. Also factors such as partner opportunism [12] encourages alliances to build up their strategy to focus on short-term measures to control the relationship in the alliance.

Anderson [13] demonstrates the element of short-termism by devising an input – output continuum to measure alliance performance in terms of short-term measures and longer-term orientations. Short-term measures locate themselves towards the output end of the continuum while the longer-term orientations, towards the input end. Through this continuum, she posits that alliances could either perform well in input measures through their current actions and perform poorly in the output measures, or vice versa. This shows that success in the short-term does not automatically guarantee long-term good performance and a performance which is overly long-term orientated might result in inefficient performance in the short-term. It is therefore inferred from her work that a balance short and long-term approach in alliance strategy is advocated.

Drawing upon March [14], the strategy of seeking significant short-term benefits, can be seen as reducing opportunities for alliances to engage in explorative work that adds more value in the future out of collaboration and increasing exploitative work of the existing skills and capabilities targeting existing opportunities. The rationale of this behaviour is linked to certainty of results, speed at which results are gained, proximity and clarity of feedback tied with exploitation rather than exploration of new opportunities, new skills and capabilities. As both exploration and exploitation compete for scarce resources, due to the proximity and speed of results tied up with exploitation, efforts are directed usually towards exploitation strategies.

3. Research Problem and Hypothesis

The work of March usefully rationalises the dichotomy between short-term and long term orientations in alliance strategy. This shows the dilemma faced by alliances in general that certainty of results, speed at which results are gained, proximity and clarity of feedback tend to send alliances seeking short-term commercial advantages rather than strategic opportunities, which sustained collaboration presents. To a certain degree in construction alliances, this situation is exacerbated as a result of more short-term orientated project based outcomes compared to alliances in other industries. Hence the unique opportunity that the concept of an alliance brings in harnessing of core capabilities through collaboration between people in different companies and takes the knowledge from project to project is often under exploited.

From the discussion, the following research problem is articulated in the following hypothesis.

> "Currently there are concerted efforts in construction alliances targeted at performing collaboration as a means of gaining short-term competitiveness and this emphasis will have a negative impact on alliances' long-term progress towards sustainable competitive advantage, if these efforts are not concentrated on leveraging collaboration as a core capability"

4. Case study methodology

The study adopts the case study approach for investigating the business logic behind the development of knowledge sharing to achieve sustainable competitive advantage within construction alliances. Case study approach is adopted based on the exploratory type and nature and the content of the stated research problem [15]. Further, the capability of the case study approach to rely on the use and triangulation of multiple sources of data justifies the use of the approach [16]. The unit of analysis for this study is taken as the collaborative links at different levels between the alliance participants of the chosen construction alliance case study.

Face-to-face interviews were held with respondents and the interviews were recorded and transcribed for analysis. The interview results were triangulated utilising senior managers (SMs) and project managers (PMs) occupying two different levels in the managerial hierarchy (triangulation of data sources), utilising two different forms of interview guidelines (triangulation of data collection methods) and utilising two different forms of data analysis methods (triangulation of data analysis techniques). The text in transcriptions were manually coded based on the criteria of:

(i) Efforts and activities that influence alliances' progress towards achieving long term sustainable competitive advantage; and
(ii) Efforts and activities that influence alliances' achievement of short term competitiveness.

The SM interviews were further analysed utilising the cognitive mapping technique. Cognitive mapping is a technique that helps to structure, organise and analyse data by creating a map indicating the perceptions of people being interviewed [17]. Software was used to aid the mapping process known as "Decision Explorer©. By attaching a meaning to the statements proffered by the interviewees, some of their concepts were clustered, highlighted and presented in a unique way to derive a meaning. The constructed maps help in understanding some of the key issues and identifying any emerging patterns of people's perceptions on knowledge sharing.

The major limitation of this study is to do with external validity within the case study research approach adopted. The conclusions of this study can be generalised only to the type of alliance discussed under the case study.

The process of analysis is further explained in the case study discussion and analysis.

5. Case study discussion and analysis

5.1 Introduction

This case study forms a part of the Channel Tunnel Rail Link (CTRL) project. CTRL covers mainly civil engineering work involving a 109 km long stretch of road and associated structures running from Folkestone, through Ashford in Kent, to a new terminal at St. Pancras station in Central London. Data collection under this case study focuses only on contract 342 of the CTRL project. The total project, as well as the case study project, follows a target cost contract under the New Engineering form of Contract (NEC), where the contractor is reimbursed its actual costs plus a fee for overheads and profits. Under this contract any total cost over run or cost saving, when compared to the target cost, is shared between the contractor and employer in a pre-agreed way. The objective of this contract is to motivate the parties to decrease costs, without affecting quality or delivery in order to maximise contractor profitability and client savings.

The project started in January 2002 and is scheduled to be completed in January 2006. The contract sum of the 'contract 342' project is £120 million. This does not include the feasibility, design and project management components of the cost to compare with the total cost of the project. However, in UK construction terms the scale of the project (as identified by the contract value) is sufficiently large and complex to demand the formation of joint ventures among contractors.

The case study focuses on section two of the CTRL project. The main contractor of the project is a contractual joint venture between HO (UK) Limited and NH Construction Limited. This alliance is referred to as HN Alliance (the true identity of the alliance and its partners are withheld for purposes of confidentiality). NH Construction Limited classifies the contractual joint venture (between HO and NH) as a joint arrangement, which does not create a separate entity. The joint arrangement is based on a 50:50 profit sharing agreement between HO and NH for the execution of Contract 342. These details indicate that this alliance belongs to the 'one-off project partnering' type or contractual type of joint venture.

A major task of this project is the sliding of two prefabricated structures (designed by the contractor) below the North Kent railway line. The first structure is a 2300 tonne open base box culvert 56 metres long and 8.5 metres high. The second structure is a three span bridge weighing 9100 tonnes, which now carries the North Kent line over the future CTRL lines. This bridge is one of the heaviest ever slid in the country. The unusual step of sliding the bridge complete with deck and full foundations was taken in order to minimise disruption to the existing railway.

5.2 Alliance partners

HO (UK) Limited and NH Limited are the main alliance partners. Both companies engage in international construction projects. HO's main base is in Germany and HO(UK) is the branch company in the UK, whereas NH Limited is a UK based contractor having projects on a worldwide scale. RLE is a consortium which is entrusted with the role of design and project management of the construction of the CTRL. HO, NH and RLE completed Contract 420 of the CTRL project in 2001. A significant number of people particularly the SMs and part of the PMs working in the case study project (Contract 342) continued from the previous Contract 420. The organisation chart of the alliance is depicted in Figure 1 which includes the people who were interviewed under the case study

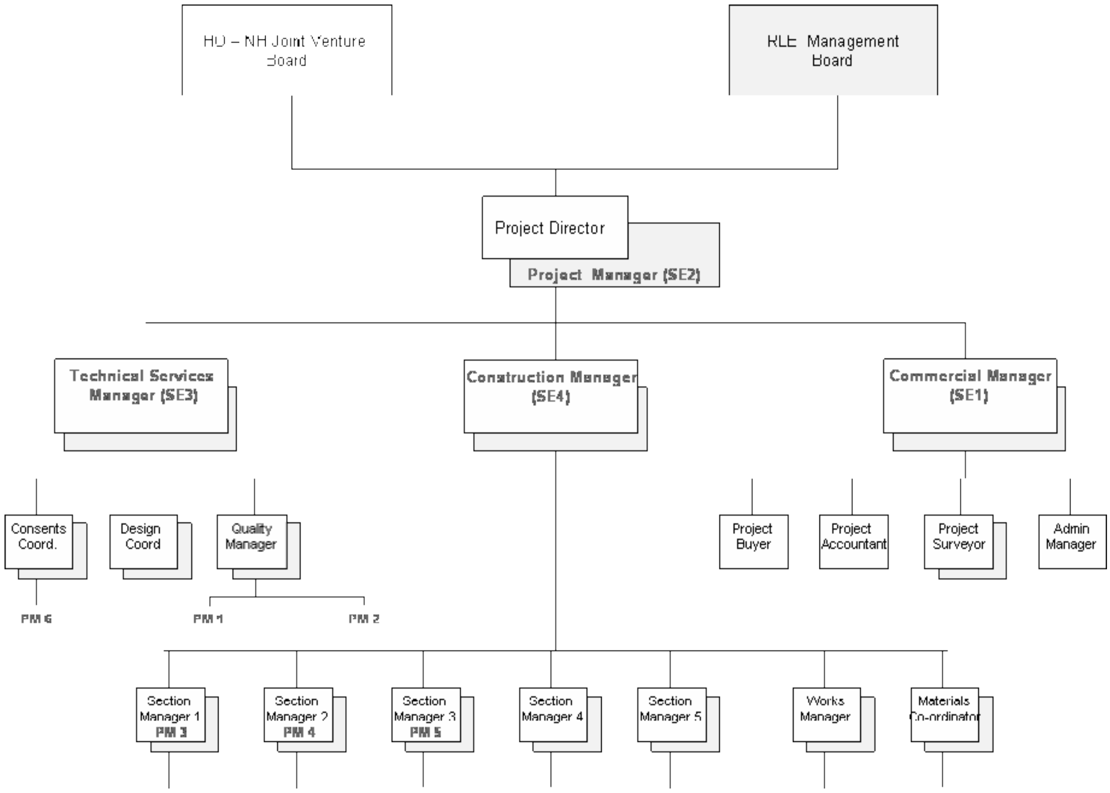

Figure 1: Cognitive map depicting SM perspectives

5.3 Data collection

Interviews lasting for more than one hour were conducted with senior managers (SMs) and project managers (PMs) according to the methodology set out earlier. SM1 is the commercial director representing HO company, SM2 is the client's advisor representing RLE, SM3 is the technical services manager representing HO company and SM4 is the construction manager representing NH company.

SM1, as the commercial director, deals with the entire procurement role for the project. Apart from procurement of materials, contracts management including management of sub contracts and accounting roles also come under the purview of SM1. SM2 performs the distinctive role of the client's advisor on behalf of RLE and covers areas such as verifying the payments due each month, and performs roles such as interacting on the design and project management of the project. As SM2 represents RLE, she has an indirect relationship with HN alliance, however the day to day interactions with the HN alliance staff justifies the selection of SM2 in the interview process. SM3 as the technical services manager is in charge of technical issues such as quality control for the project. SM4, as the construction director, is in charge of all the section managers for the construction of the project. In addition, six middle and junior level managers were interviewed. They are denoted as PMs for purposes of reference in this chapter. Individually they are referred to as PM1, PM2, PM3, PM4, PM5 and PM6.

5.4 Methods of Collaboration

Since the alliance operated in a construction site, the team mainly utilised face-to-face meetings for collaboration purposes. Apart from the regular site meetings, they initiated face-to-face meetings when the engineers and section managers face unanticipated problems in the project to brainstorm ideas on how to solve the problems. These meetings are called "early warning meetings." Decisions are reached based on the discussions at the meetings. Once a solution is found, the meeting is concluded. The discussions at these meetings are problem focused and only encourage ideas, which are focused on the problem. These meetings take place on an adhoc basis as problems arise. Apart from the face-to-face meetings, the alliance also utilised emails, a shared file server (known as the 'I' drive), an electronic document management system and an Intranet for purposes of sharing and collaboration.

6. Results and Discussion

Responses received from both SMs and PMs were coded based on how they are linked to short / long term orientations based according to the criteria set out in the methodology. A cognitive map was built around SM perspectives and is detailed in Figure 2. PM perspectives are detailed in Table 1.

SM perspectives (see the two combined SM view points given in Figure 2) indicate the role of risk sharing in the alliance as creating both a negative and a positive knowledge sharing climate within the alliance. SM1's comments highlight the criticality of events associated with the significant level of design tasks undertaken by the contractor. Integration of design and construction roles under the new NEC contract has increased the number of critical activities actioned against the contractor in the construction programme compared to forms of traditional contracts where design and construction is usually separate and the contractor only performs a construction role (for small scale projects, design and build type of procurement system is used, which integrates design and construction). Under a traditional contract, the detailed design deadlines are met by designers who are separately responsible to the client. Therefore, the integration of a major part of the design with construction increases the occurrence of a delay in the project compared to a traditional contract where the contractor only executes construction work. However, SM1 shows how some of their strategies attempt to build up a learning relationship by making them learn from each others' experiences among the people working in different sections of the project. Further, the awareness of the consequences of a delay prompts SM4 to suggest that the management has to adopt strict measures to limit the number of meetings including actively participated “early warning meetings” so that a significant amount of resources are deployed at achieving critical deadlines. This strategy is adopted at the expense of sustaining the early warning meetings. Frequent visits by the members of the board of directors for site progress reviews also influence the alliance staff to show tangible results in terms of project’s progress on an ongoing basis. Such behaviour indicates that the alliance participants have reduced opportunities to participate in activities that sustain knowledge sharing within the alliance.

SM2 however, advocates a duality of views on collaborative tasks to sustain the alliance relationships. Whilst she agrees that at the top management level collaborative tasks such as brainstorming workshops are carried out which attempt to sustain the alliance relationships, she expresses scepticism whether such practices filter down into the middle and junior management levels. SM3 rationalises the decision to collaborate based on the joint venture route as a measure of sharing the risks of the project. SM3’s statement on the Intranet (see concept 14 in Figure 2) where it is mentioned that he prefers to email someone and get the information rather than look for it in the Intranet shows how a short term orientated practices manifest in reduced usage of the Intranet.

PMs on the other hand believe that the alliance route and its short term orientated work practices have a negative influence attached to it as it reduces their opportunities to sustain explorative collaborations with their colleagues. Instead they have to release a significant amount of their resources for carrying out exploitative tasks that are related to achieving project deadlines

Overall, PMs agree that the methods of capturing shared knowledge is inadequate. PM3 mentioned that a presentation was done on the “bridgeslide” operation, but it consisted of only superficial type of knowledge. PM5 contributes to this argument and points out that some of the SEs published papers related to completed projects in internal HO bulletins. However, this was done on an adhoc basis. PM3, PM4 and PM5 agree that due to the absence of an appropriate mechanism to capture knowledge, the knowledge exist only in their minds and the knowledge travels with them rather than the companies

Table 1: PM perspectives on knowledge capturing and sharing

	PM1	PM2	PM3	PM4	PM5	PM6
Role of the alliance and how it influences knowledge capturing, sharing and transfer	1. All the engineers (junior managers) are ready to use electronic documents (drawings). But middle managers upwards are fighting a battle.	1 lot of duplication between the RS UK system and the 'infoworks' system, due to contractual conditions	1. I only use the site query facility in the Intranet	1. This particular area is site specific. There is no database produced to capture great ideas. Perhaps it is only the people who have experience and the knowledge who walks away with them rather than with the company. Also I am site based and not aware as to what is going on in the head office.	1. We capture knowledge and when we got to work at another site we take the knowledge with us.	1. We do voluntary knowledge capturing to our head offices.
	2. The intranet is perceived by many people as a glorified phonebook. Therefore does not relate to what I am doing and I don't use it.	2. A majority of the people do not have access to the Intranet. But the Intranet fulfils my needs, All I want to know is there in the Intranet	2. Bridge slide experience involved 100's of day to day incidences. There were many "bright ideas". However these only exist in our minds. There was no capturing of this new knowledge. Although a presentation was done on the bridgeslide, this is just a one off exercise.	2. designers send design queries through the Intranet.	2. Email has become a tool to prove that you are doing your job.	2. Telephone is used to check whether a person is available before going to a face-to-face meeting.
				3. We get a lot of emails, telephone calls and we have to attend a lot of meetings. Usage is pretty even.	3. Intranet and the discussion forum facility in the Intranet (Site query facility) is not used much, The reason is that so many people are involved and difficult to keep a track.	3. Design coordination involves liaison with a large number of people.

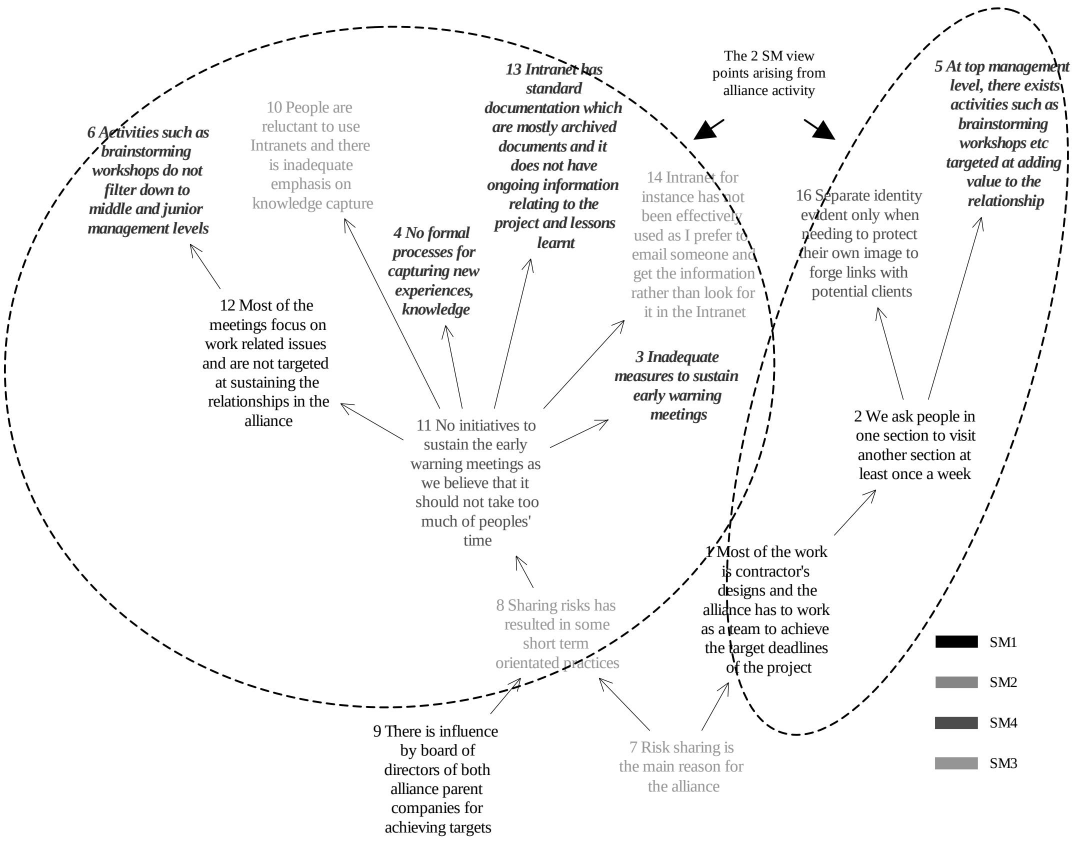

Figure 2: Cognitive map depicting SM perspectives

The SMs communicate tasks to the PMs utilising short messages in the form of instructions via email (SM - PM), which are adequate for the PMs to execute the work involved. While it ensures that the tasks that need to be performed by the PM’s are successfully executed and the project deadlines are to a large extent satisfactorily achieved, the process reduces the opportunities for SMs and PMs to engage in an evolving dialogue. Therefore the philosophy of programme management and achievement of key deadlines and milestones draws heavily upon the resources of the alliance particularly with respect to the input that PMs can make towards activities that add value in the long run.

The overall alliance direction therefore is significantly focused on short term orientated commercial advantages rather than long term sustained collaboration. Although SM-SM collaborations are framed with a view to long term orientation, the SM – PM and PM – PM collaborations are significantly short term orientated. The hypothesis set out in this paper has therefore been confirmed. The next section provides the conclusions of this paper.

7. Conclusions

Review of literature on alliances show that the concept is gathering momentum within the construction industry. Initially this paper argued that efforts and activities conducted by construction alliances are short term orientated and this significantly affects their performance in the longer term. The empirical investigation as detailed in the paper supports this theoretical justification within the HN alliance. The case study results provide added support to the claim that the short term orientation existing within construction alliances has adversely affected the core capability development process and resulted in reduced scope in achieving sustainable competitive advantage. The study therefore confirms the existence of the “project based mindset”, among senior, middle and junior managers within construction alliances. This overly narrow project focus constrains the process of achieving sustainable competitive advantage. The study reveals that the longer term aspects of collaboration in construction alliances are not adequately appreciated or understood in practice or in theory. This research addressed the value of long term collaboration and improving effectiveness and efficiency of interactions between construction alliance participants to improve knowledge sharing, thereby influencing construction industry practices. Although long-term partnering trends have emerged in construction, the research findings indicate that they have failed to fully break the “project based mindset” mould in construction.

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Output differences of specialist firms in the UK building industry: a contingency approach using the heating and ventilation industry

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Abstract

The construction sector is comprised of several specialist sub-industries, each with its own specific characteristics. Many of the firms in these sub-industries are the subcontractors that form the interface between construction and material suppliers. The specialist firms in the building industry tend to carry out the transformation of materials into finished structures. There is therefore a need to understand the complexity of the fragments of the construction process in order to manage it effectively.

Making use of detailed published data, the time series of the output of various sub-industries from 1959 to 1997 are compared. Output at constant prices and indices of output are used to show that different specialist industries' patterns of growth varied greatly. Using a contingency approach, the heating and ventilation industry can be used as an example of one specialist sub-industry, to show how the output of one industry differed over time from the output of the industry as a whole. This approach linking historical events and conditions to changes in heating and ventilation output produces evidence of sub-sector behaviour that may not necessarily apply to other parts of the building industry.

However, changes in any one specialism are only partly caused by changes in the construction industry as a whole. Other economic factors and technical changes affecting heating and ventilation firms alone imply that it is not appropriate to generalise about all firms in construction. An appreciation of these sub-sectoral differences would assist in the management of the construction procurement process.

Keywords: construction industry, contingency approach, specialist firms, heating and ventilation industry.

1. Introduction

Much research into the construction industry has focused its attention, though not exclusively, on main contractors, as has most of the literature, including text books like Raftery (1991), Ruddock (1992), Gruneberg (1997) and Myers (2004) or even the more advanced works like Ball (1988), Hillebrandt (1984) and Hillebrandt and Cannon (1989 and 1990) and papers such as Kale and Arditi (2001). Most commentaries on the construction industry are given from the point of view of main contractors, usually assuming them to be large firms. Although Latham (1994) and Egan (1998) both refer to subcontracting, the former is mainly concerned with the problems of main contracting and the latter is focused on clients' needs.

They examine the construction industry from the point of view of main contractors who engage subcontractors to carry out specialist work packages. However, this perspective has become increasingly obsolete as main contractors have, with one or two exceptions, shed direct labour and used less and less of their own equipment. Although their management role ensures that main contractors retain a high percentage of the construction costs of clients, a smaller proportion of the actual building process is undertaken in-house than previously.

Although there are indications that a few large UK contractors may be reversing this trend, the strategy of survival of main contractors has been to use specialist contractors, to employ labour only subcontractors, and to hire plant. Currently, main contractors have transformed themselves into management contractors providing professional management skills and knowledge. Therefore a gap, though by no means a vacuum, has opened up in the literature concerning the central role of specialist firms in the construction industry. Relatively little work has been carried out on subcontractors apart from Hillebrandt (1971), Clarke (1981), Ive (1983), Gray and Flanagan (1989) and more recently Hughes, Gray and Murdoch (1997) and Constantino, Pietroforte and Hamill (2001).

Gray and Flanagan (1989) describe building work on site as a process of assembling prefabricated components. It is a mixture of many trades and techniques, materials and plant. As the number of manufactured components increases, the firms supplying these are often used to assemble them on site employing their own dedicated and trained workforce. Other firms specialise in fixing particular types of components supplied to them by particular manufacturers. This is the case, for example, with heating and ventilating contractors.

It is not possible to generalise about subcontractors in construction because of the large variety of types and sub-industries in which they operate. For example, the form of subcontracting depends on the variety of functions and roles the subcontractors are expected to undertake. Gray and Flanagan (1989) define four categories of subcontractor according to their contribution to the building process. Their four types are;

- fix only
- supply and fix
- design, supply and fix, and
- full design, manufacture, supply and fix.

Alternatively, the population of construction industry subcontractors could be divided according to type of technology, materials used, skills or differences in capital structures. As firms in specialist building markets often have little in common with specialist firms in other sub-industries, what may be true of one sub-industry does not necessarily apply to another. Specific technologies, labour skills and capital structures mean that any in-depth research must focus on firms within a particular specialism, such as heating and ventilation firms.

If construction firms are different the question is how different are they? One indicator may be differences in output of different specialisms compared to construction output as a whole. Total construction output is the aggregate of all firms engaged in construction work. If there were no differences between them, then all specialisms would respond to changes in construction output in the same way. In this paper time series of total construction output and the output of specialist sectors over time are shown to differ. Taking heating and ventilation firms as an example of one specialism, the unique circumstances of one sub-industry are discussed.

Following the method statement the growth pattern of total construction output is compared to the output growth patterns of the different specialist firms from 1959 to 1997. This is followed by a section, which deals with the particular case of heating and ventilation engineers in the same period. The concluding section summarises the findings and confirms the differences between specialist contractors require different approaches to each specialist market.

2. Method

This paper represents a first examination of existing data and is purely indicative. The data sources used are taken from the DETR Housing and Construction Statistics (now the DTI, Annual Construction Statistics). Data on the heating and ventilation industry has been taken from the Annual Reports of the Heating and Ventilating contractors Association (HVCA).

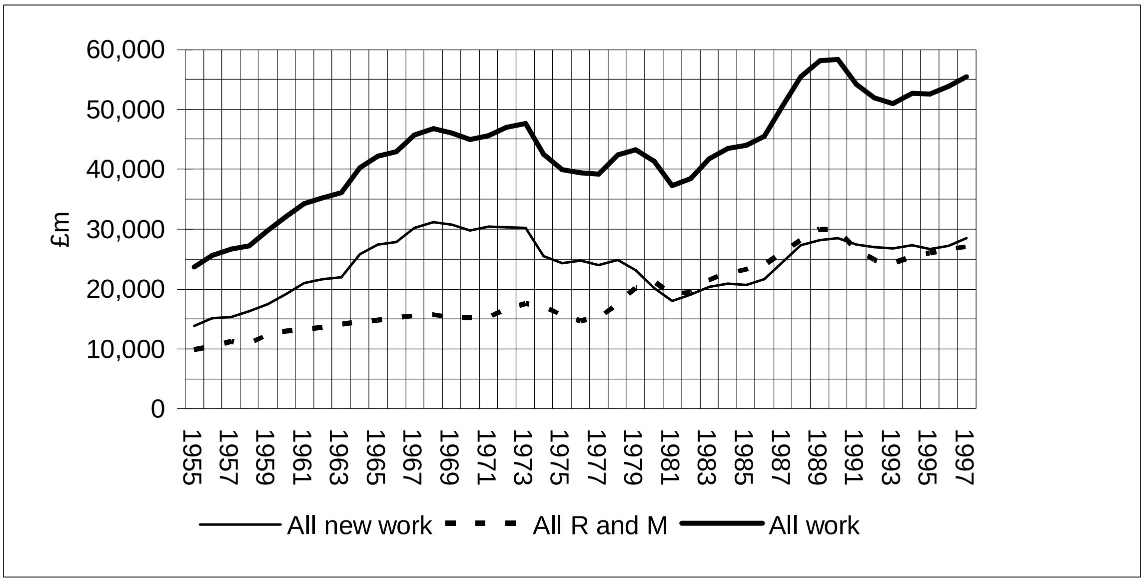
The method used to deflate the data is based on the implied deflators calculated from the DETR's constant price and current price data and has been referred to in this paper as the Gross Construction Price Index, GCPI). The paper combines data on a large number of different specialisms within construction and this time series data is compared visually.

The particular circumstances of the heating and ventilation industry since 1945 can be traced using the annual reports of the Association of Heating, Ventilating and Domestic Engineering Employers (AHVDEE), which became the Heating and Ventilating Contractors Association.

3. Comparison of the output of the construction industry and specialist construction industries

If firms in different specialisms respond to changes in construction demand in the same way, then patterns of growth in the different specialisms would follow the pattern of growth of construction output. The long-run trend in construction output in the UK since 1945 can be divided into three periods. The first was the period of immediate post-war reconstruction, which lasted until approximately 1950. The second was the long boom from circa 1950 to circa 1968. The third period lasted from 1968 and can be characterised as a long period of instability. The third period of instability itself can be divided into three shorter phases. The first phase from 1968 to the early 1980s was a period of declining output in construction. From 1981 until 1990 construction witnessed expansion. In 1991 the construction industry experienced the start of a recession with recovery only beginning to appear by 1994.

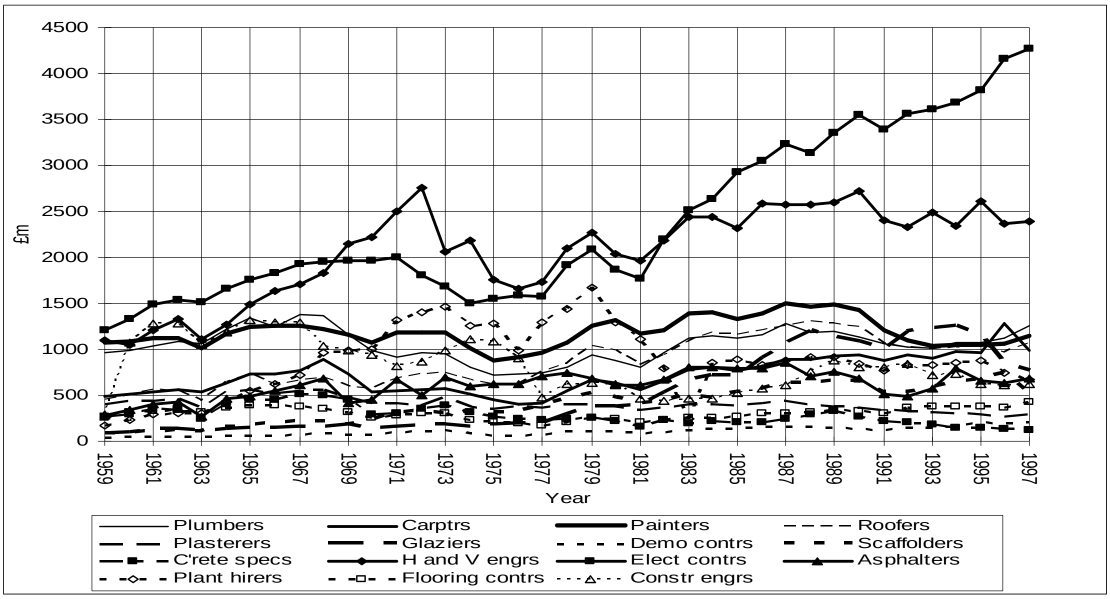
Figure 1 uses the DETR series of total construction output in Housing and Construction Statistics. The time series show total construction output, new work and repair and maintenance from 1955 to 1997.



Source: Data at 1995 prices provided by DETR.

Figure 1: Total construction industry output, new work and repair and maintenance 1955-1997

Although demand, output and costs of the construction industry as a whole clearly encounter variations, the size of these variations at the aggregate level, according to Ball (1988 p.98), are not ‘peculiarly volatile’. Real annual new work rose steadily from £13,800m in 1955 to £31,200m in 1968. The year of greatest new build output in real terms was 1968. From 1955 to 1968 repair and maintenance rose steadily from £9,900m to just over £15,700m but then became more volatile. During the 1980s repair and maintenance even represented a higher percentage of construction output than new build. The output of firms and specialisms depends on their mix of new build and repair and maintenance. As each specialism differs from the others in terms of the proportion of new build and repair and maintenance they undertake, changes in their annual total outputs are also different.



Source: Private Contractors Census, Table 3.3, Housing and Construction Statistics, Annual

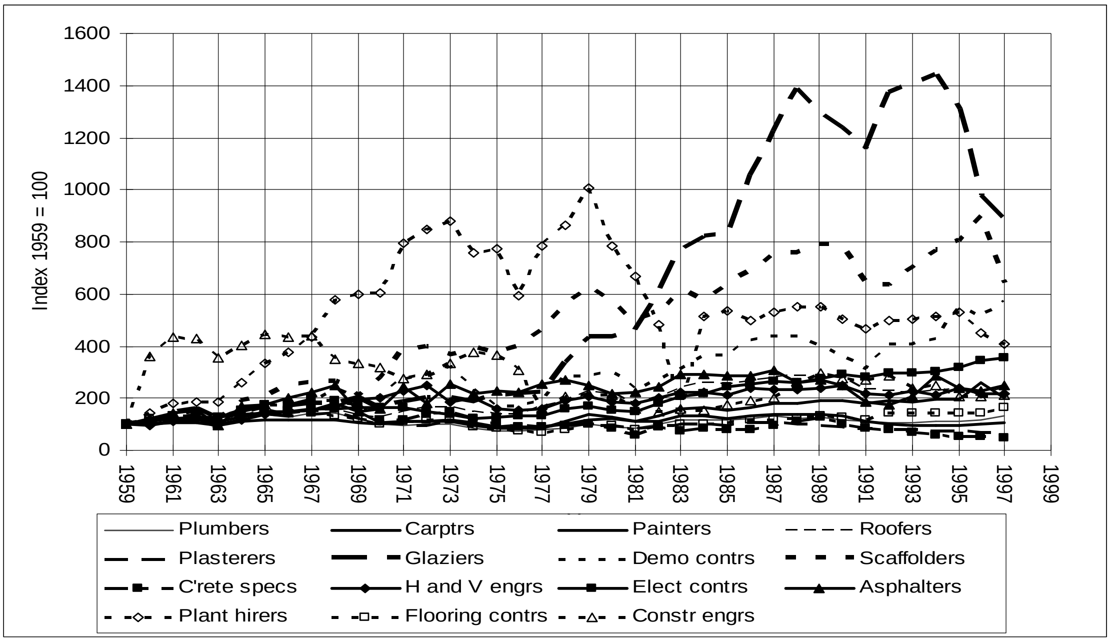
Notes: Carptrs = Carpenters and joiners; Demo contrs = Demolition contractors; Scaffolders = Scaffolding specialists; C'rete specs = Reinforced concrete specialists; H and V engrs = Heating and ventilating engineers; Elect contrs = Electrical contractors; Asphalters = Asphalt and tar sprayers; Flooring contrs = Flooring contractors. Constr engrs = Construction engineers

Data deflated using the GCPI 1995 = 100.

Figure 2: Work done by a number of specialisms in the construction industry1959 to 1997

Figure 2 shows the value of work done by a number of different specialisms within construction. In particular the graph highlights the growth of heating and ventilating contractors and electrical engineers. Always the largest two specialisms, together they increased their size relative to the other trades. Other trades appear to grow at a much slower rate. However, although heating and ventilation output can be seen to increase rapidly in the period up to 1972, since 1972 it remained more or less at a similar level of output. In contrast the value of electrical engineering work done continued on a long run upward trend.

Figure 2 confirms the received wisdom that mechanical and electrical contractors increased their relative share of construction output between 1959 and 1997. The value of output of all the remaining specialist trades tended to remain below £1.5bn, most showing little tendency to grow in real terms between 1959 and 1997. However, Figure 3 shows more clearly that between 1959 and 1997 changes in the value of output of different trades were greatest in the glazing trade, scaffolding and plant hire. Output of electrical contractors and heating and ventilating engineers did not grow significantly more than in most other trades. Figures 2 and 3 demonstrate that all trades were not equally affected by changes in overall demand.



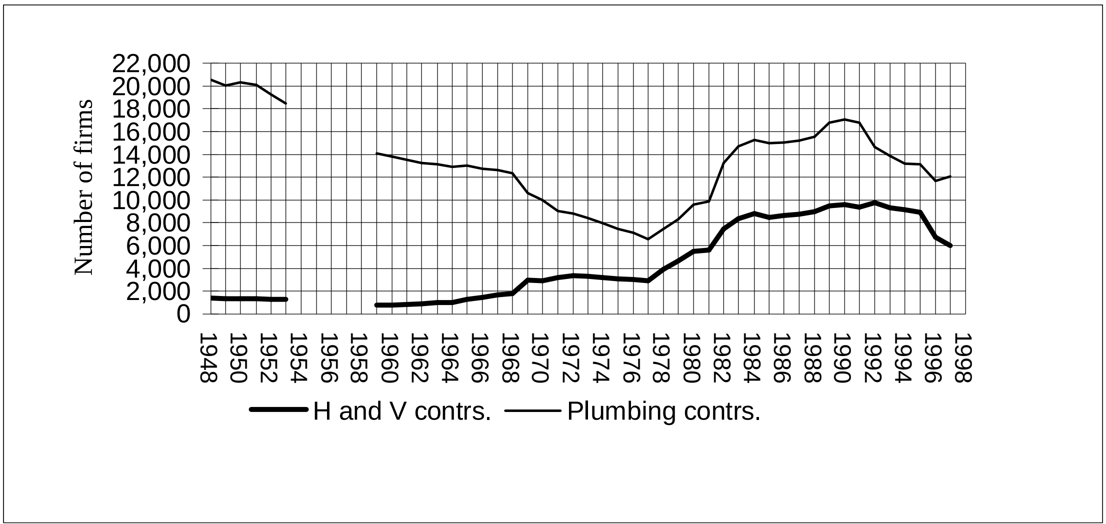
Source: Private Contractors Census, Table 3.3, Housing and Construction Statistics, Annual
Data deflated using the GCPI 1995 = 100.

Figure 3: Work done by a number of specialisms in the construction industry 1959-1997

Demand for construction services is a major determinant of construction output. However, other influences play an important role in the performance of different sub-industries. Thus changes in technology and improvements in productivity may have enabled firms to produce more buildings and structures per annum. However the value of construction output may not have risen to reflect the increased output if the real unit cost of construction declined, a phenomenon more obvious in the computer hardware industry where unit prices of personal computers declined while the power of computers increased. The following section traces the particular circumstances of the heating and ventilation industry as an example of the particular factors, which affect specific industries and lead to performance differences.

4. The heating and ventilation industry

Heating and ventilation contractors assemble specialised equipment to heat or ventilate buildings. In 1949 the Council of the Association of Heating, Ventilating and Domestic Engineering Employers (AHVDEE) conceded that the heating and ventilating industry formed ‘a very small part of the industrial whole and was a very recent development as a branch of engineering’ (AHVDEE, 1949 p.119). Since the Second World War the number of firms in the heating and ventilating industry grew from less than 2,000 to a peak of almost 10,000 firms in 1992. Figure 4 contrasts the growth of the number of firms in the heating and ventilation industry compared to the number of firms in plumbing, a closely allied specialism. From 1948 to 1977 the number of plumbing contractors fell while the number of heating and ventilating firms grew moderately. Since 1977 the number of firms in both specialisms followed similar patterns, due to changes in employment patterns towards casualisation of labour and the formation of a large number of small enterprises, which occurred throughout the construction sector.



Sources: Annual Private Contractors' Census and Housing and Construction Statistics, DETR

Figure 4: Heating and ventilating contractors and plumbing firms, 1948-1996

To view the relative importance of the heating and ventilating specialist subcontractors compared to the industry as a whole in terms of the number of firms and employment, Table 1 provides the number of firms operating in various years. The percentage of employment in each type of firm is also given for 1985, 1990 and 1996. Heating and ventilation only constituted 6 per cent of employment of all trades in 1985, dropping to 5 per cent by 1996. Relative to the rest of construction the heating and ventilating firms did not increase their share of employment although as Figure 2 shows, output more than doubled in real terms.

The particular circumstances affecting the heating and ventilation industry can be best explained by the economic influences occurring at different times. In the late 1940s, for example, the heating and ventilating sector was cushioned to some extent by the need to save fuel as coal prices were tending to rise. There appears to have been a rather chaotic switch from coal to oil fired installations and back again to coal. In themselves these shifts by no means harmed heating and ventilating contractors. Conversion work meant full order books for contractors and full employment in the trade, a level of demand that was expected to continue (AHVDEE, 1948, p.99).

Table 1: Number of heating and ventilating contractors compared to different types of building firms between 1973-96 and employment in 1985 and 1996

Trade	**Number of firms** [1]					**Emp. %** [2]	
	1973	**1977**	**1985**	**1990**	**1996**	**1985**	**1996**
General builders	39659	31889	67475	78981	50615	34	26
Building and civil engs.	2364	2054	3623	4773	4984	15	9
Civil engs.	2114	1633	2662	3742	10781 [3]	6	8
Total main trades	44137	35576	73760	87496	66380	55	43
Heating and ventilation contrs.	**3284**	**2906**	**8461**	**9624**	**6697**	**6**	**5**
All other trades	49155	39160	85604	112673	90238	39	52
Total all trades	96576	77642	167825	209793	163315	100	100

Source: Housing and Construction Statistics 1978-88 and 1987-97 Tables 3.1(b) and Table 3.5 (b)

Notes: [1] Table 3.1(b)

[2] Percentage of total construction employment

[3] There is a discontinuity in the series in the series of civil engineers between 1995 and 1996 relating to increased coverage especially of firms with 7 or fewer employees, which accounts for the rise in the number of firms.

Thus the heating and ventilating industry may not have followed the same cyclical pattern as the rest of the building industry in the years immediately after the war. After the immediate post war expansion in building work, the government cut spending on construction without an increase in private sector demand to compensate. From 1948 to 1951 total construction output actually fell in real terms (Smyth, 1985, p.124). This was followed by a period of growth in construction output, which began in 1951, and continued steadily though slowly until the end of the 1960s.

The heating and ventilating industry also remained relatively steady and growing throughout the 1950s. This expansion continued into the 1960s and beyond reaching a peak in 1973, according to DTI output data**.** The comments in the Council's 1962 Annual Report were characteristic of the optimism in construction at this period. According to the Annual Report of the AHVDEE total output of construction had increased by 5% in 1961, with heating and ventilating work probably increasing more, in spite of periods of slack due to declining industrial orders (AHVDEE, 1962, p.13).

Indeed, optimism was expressed due to the increasing content of mechanical services in buildings. The turnover of the heating and ventilating industry continued to expand. This growth had been mainly in the domestic heating sector, while demand for heating and ventilating systems in new office developments at the time declined, according to the HVCA (HVCA, 1964 p.7). The increase in domestic work was largely a result of advertising campaigns by the oil, coal and gas industries, rather than any specific marketing activity on the part of the heating and ventilating industry itself. Although materials were still readily available and apparently giving no cause for concern, worries about skill shortages on and off site were beginning to be expressed (HVCA, 1965 p.7). Skill shortages are a sign that an industry is approaching full capacity, affecting its ability to maintain its rate of growth.

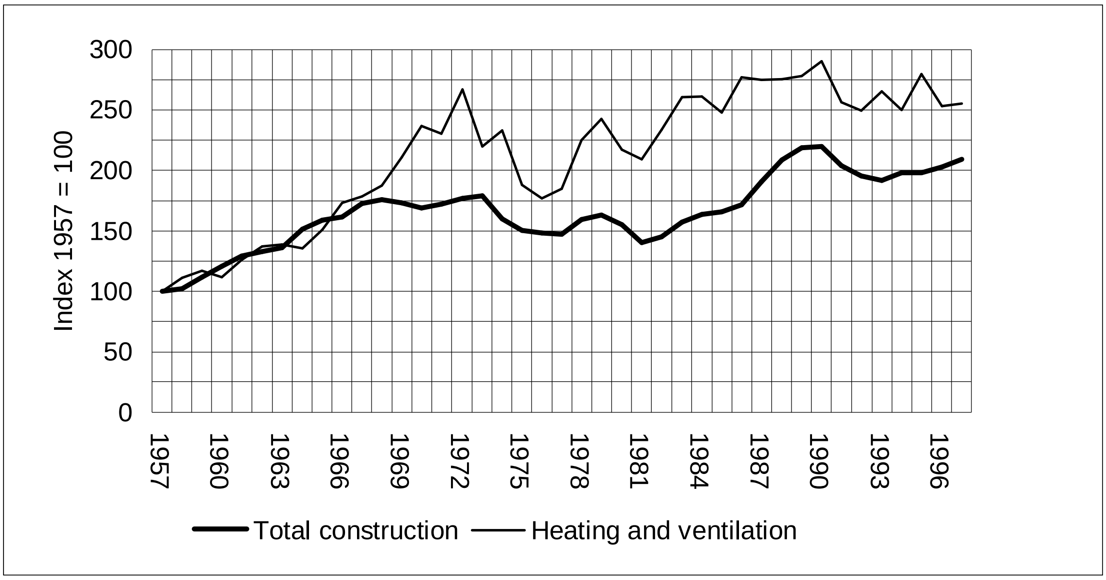
5. Heating and ventilation and total construction

The experience of firms in the heating and ventilation industry was not the same as firms in the rest of construction. Figure 5 illustrates the similarities between construction output as a whole and the heating and ventilation industry between 1955 and 1997. There is evidence that the heating and ventilation industry did not follow the pattern of construction output in the short run. However, in the long run movements in construction tend to be reflected in the heating and ventilation industry. The long run expansion from 1955 to the early 1970s, followed by the decline in the mid 1970s and the recovery from 1981 to 1990 are all apparent in Figure 5. However, in several years the direction of change in the heating and ventilating industry is the opposite of construction as a whole. This implies that while demand for construction influences demand for heating and ventilating engineers in the long run, in the short run factors other than construction demand play a significant role.

For example, in 1969 construction demand declined but the HVCA maintained that total demand for the heating and ventilating industry had been comparatively unaffected (HVCA, 1970 p.7). Indeed, according to DTI output data, while construction output fell slightly between 1968 and 1970, heating and ventilating industry output actually rose by around 15 per cent per annum in the same period. Increases in oil prices in the early 1970s may have caused problems in terms of inflation and the balance of payments. However, for firms in the heating and ventilating industry it meant they were employed to adapt buildings in response to the changed relative energy prices. This provided a respite for heating and ventilating firms during one of the worst declines in output since the Second World War. This respite occurred although the domestic consumer market was constrained to some extent by government credit restrictions in force at the time, a factor, which did not affect all parts of the construction industry equally.

Again the particular circumstances of the heating and ventilation industry can be seen in the period between 1974 and 1977 when total construction demand was in decline. The HVCA reported that demand for heating and ventilating continued at a high level in 1974. This may have been related to additional work caused by the sudden rise in oil prices in 1973, stimulating demand for non-oil heating systems after a time lag of a year. Nevertheless, by 1976 even the heating and ventilating industry reflected the decline in the rest of construction. The HVCA guessed that the output of the heating and ventilating industry had dropped by 5-10 per cent between 1976 and 1977 and was on a downward trend (HVCA, 1977 p.31).

In 1982 the decline in construction output halted, but demand for construction remained at low levels throughout the year and a record number of HVCA members went out of business because of the level of competition, and continuing over-capacity combined with cash flow problems (HVCA, 1984, p.8). Those heating and ventilating contractors who had survived the recession, like other firms in the construction industry, were prepared to tender at extremely low prices for the limited opportunities available. However, the HVCA reported that towards the end of 1982 demand began to increase and by early 1983 construction orders were over 15 per cent above the level of a year before (HVCA, 1984, p.8). Moreover, recovery of demand for heating and ventilating was far more rapid than for construction as a whole.



Source: Heating and ventilating industry, HCS; Construction industry output data supplied direct by DETR
HVI data deflated using the GCPI. CI data at 1995 prices

Figure 5: Annual output of the construction and heating and ventilation industries 1957- 1997

Between 1992 and 1997 heating and ventilating contractors experienced highly volatile changes in demand. Their output increased by 10 per cent between 1994 and 1995 but dropped by a similar proportion the following year. In the same period recovery from the recession of the early 1990s in the construction industry as a whole was slow and steady. Heating and ventilation contractors were engaged on a large number of large speculative office developments which, by 1994 and 1995 required their services.

We have noted a number of specific factors influenced the performance of heating and ventilating contractors, such as increases in the demand for mechanical services in buildings, changes in the relative energy prices, and shifts in work between different types of buildings. Nevertheless, much of what occurs in construction occurs in response to changes in demand for its services, not only in the types of buildings specified but also the total value of building work. This brief history has demonstrated that it is insufficient to predict changes in the heating and ventilation industry by only examining demand for construction as a whole.

6. Conclusion

The fragmentation of the construction industry into specialist sub-industries can be shown to exhibit completely different performance patterns. These divergent patterns lead to complexity in terms of the composition of the construction industry not only in terms of shares of the total output of the construction industry but also in terms of the numbers of firms active in each sub-sector.

This has been an indicative paper highlighting the need for further research into small and medium sized enterprises in the construction industry and much more work and analysis of the different specialist firms and markets throughout the sector. There is a need to know the characteristics of each market, the operating methods used by firms and the historically contingent institutional arrangements which determine the way business is conducted in each sub-sector of construction.

This paper has dealt with some of the particular economic factors influencing the heating and ventilation industry. However, these factors are only a partial explanation. Technical factors also play a role. Technical change, innovation and new products also play a part in affecting demand for the services of heating and ventilation firms, the productivity of the workforce and the profitability of firms, and these factors are unique to each specialism.

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A Review of Competition in South African Public Private Partnership Procurement

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Abstract

This paper reviews the procurement of Public Private Partnerships (PPPs) in South Africa focusing on the competition for their award. It uses the legislative and regulatory frameworks and the relevant guidance documentation in place that govern PPP procurement and the subsequent service delivery as evidence of the practices in South Africa. The paper comments on: the ensurance of competition intensity through the attraction of an appropriate number and quality of private parties to bid for a PPP, avoidance of erosion of the client’s bargaining power in the preferred bidder stage, and prevention of anti-competitive collusion and predatory behaviour by the bidders. The review reveals that the foundations for PPPs in South Africa offer sophisticated solutions for fostering competition in PPP procurement. These solutions include: the use of prequalification to select the appropriate private sector bidders, the utilisation of bid bonds to ensure the bidders’ commitment to the procurement process, the appointment of a reserve bidder to maintain client’s bargaining power in the preferred bidder stage, the execution of due diligences early on in the procurement process to prevent changes in the details of the project during the uncompetitive negotiations leading to financial close, and the use of public sector intervention to prevent collusion and/or predatory behaviour. Thus, South Africa appears to have a robust procedure in place for organising PPP bidding competitions. However, there is a distinct lack of evidence on the level of competition that this procedure induces on actual projects and, thus, it is not known whether it enables public sector clients to obtain improved value-for-money PPPs in practice. As a result, this paper calls for future research into PPP bidding competitions in South Africa.

Keywords: Public Private Partnership (PPP), procurement, competition, bidding, auctions, South Africa

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1. Introduction

According to the South African National Treasury (2004a, 4), a Public Private Partnership (PPP) is *"a contract between a public sector institution and a private party, in which the private party assumes substantial financial, technical and operational risk in design, financing, building and operation of a project."* In line with the established construction industry terminology, this paper refers to the public sector institution that procures a PPP as the client. The private party that either pursues or undertakes a PPP is often a consortium of private sector actors governed by a complex set of contracts and arrangements. These actors can range from contractors to facilities management service providers and financiers.

A public sector client procures a PPP in order to generate benefits to society. In a PPP, the private party provides a support service (e.g. serviced healthcare accommodation) to the client that it consumes as part of its core service (e.g. healthcare) provision to the public. Alternatively, the private party may provide a core service (e.g. transportation) to the public directly. The private party is compensated for its support or core service provision either by the client or the client may permit it to recover user charges from the consumers of the service. The compensation may also be a combination of these two approaches (National Treasury, 2004a). A private party competes for a PPP because it anticipates that the revenues it would obtain as a result of being awarded the project will be greater than the costs it will incur for fulfilling its obligations under the contract and, thus, make a profit.

This paper reviews the competition for PPPs in South Africa. It uses the legislative and regulatory framework and the relevant documentation used to govern PPP procurement and the subsequent service delivery as evidence of the practices in South Africa. The paper explains the underlying logic of the prescribed practices and, through analysis, highlights a number of issues that require further investigation. Section 2 explores the role of competition in the procurement process. Section 3 discusses the role of a robust legislative and regulatory framework and associated guidance documentation in fostering competition. Section 4 investigates the client's strategies to enhance competition by improving the quantity and the quality of private parties participating in bidding competitions. The client's tactics to deal with decreased competitive pressure in the preferred bidder stage are examined in Section 5 and its ability to manage collusion and predatory behaviour of the private sector actors is explored in Section 6. The last section concludes the paper.

2. Competition and PPP Procurement

A client organises a bidding competition in procuring a PPP in order to improve its value-for-money. The National Treasury (2004b) sees value-for-money as the difference between the risk-adjusted cost of procuring a project that would generate an identical level of benefit to society as the proposed PPP using traditional methods and the lowest cost that a private party is willing to accept for undertaking the PPP. By awarding a PPP competitively, the client is able to increase its bargaining power in relation to the private sector and either extract greater benefits, reduced costs or both from the private party that wins the contract to undertake the project. This increases the value-for-money of the PPP. The private party is willing to offer improved value-for-money to the client because by doing so it also increases its likelihood of being nominated the preferred bidder out of the private parties pursuing the project.

In terms of auction theory, the bidding competition for a PPP is a first-price sealed-bid auction (McAfee and McMillan, 1987; Riley, 1987; Milgrom, 1989). The private parties submit proposals of fully priced solutions for the project. The details of these proposals are known only to the bidders themselves, hence its name as a sealed-bid auction. The private party that is willing to undertake the PPP on the most economically advantageous terms to the client (i.e. provide the best value-for-money when benefits are measured against a specific bid evaluation criteria) is awarded the contract. The winner will be compensated in accordance with the principles it used to price its proposal. The fact that the client uses the winner's pricing (as opposed to the pricing of the bidder with the second-best proposal) as the basis for compensation clarifies why the auction is referred to as a first-price auction.

Klemperer (2002) argues that what really matters in auction design is the client's ability to foster competition for the contact and that the finer points of auction theory are of secondary importance to the success of the auction, i.e. its ability to yield value-for-money. As a result, this paper does not question the decision of the National Treasury to use a specific auction format for the award of PPPs in South Africa. Instead, it takes the first-price sealed-bid auction as a given and focuses on exploring the common pitfalls in organising such auctions that may compromise the level of competition in PPP procurement and, consequently, result in sub-optimal value-for-money.

It must be acknowledged that a client can also procure a PPP through negotiation as opposed to a bidding competition. However, the National Treasury (2004c) takes an unfavourable view of a negotiated contract award that a client can follow particularly when the client has received an unsolicited proposal from a private party because of lack of competitive pressure is likely to compromise the value-for-money of the project. According to Klein (1998), a negotiated award may be appropriate in order to either save on the cost on transacting (i.e. the cost of organising a bidding competition) or to speed up the implementation of the PPP and, thus, bring forward the stream of benefits that flows from the project. Klein (1998), however, agrees with the National Treasury (2004c) that a negotiated procedure is likely to compromise the transparency of procurement that may result in a number of problems such as increased scope for corruption. Thus, the National Treasury (2004c) recommends that if a client receives an unsolicited PPP proposal with merit, it should organise a bidding competition for a similar project. Klein (1998) points out that the downside of such practice is that it will discourage unsolicited proposals from private parties even if they might yield great benefits to the public sector if implemented.

3. Legal and Regulatory Framework and Associated Guidance

According to Sader (2000), many developing countries lack the legal and regulatory framework for the effective procurement and governance of PPPs. As a result, a private party pursuing a PPP opportunity cannot be certain that its up-front investment in the project-facility used in service provision will be protected over the project term from unanticipated public sector intervention. Considering the fact that the duration of a PPP contract can be several decades, this is a significant risk. A change in Government may, for example, result in a unilateral decision by the client to renegotiate the contractual terms of the project. The risk of such an event may deter some private parties from entering a bidding competition for a PPP and, thus, decrease the competitive pressure in procurement by either reducing the quality or the number of private parties that want to bid for the project. Consequently, the client will be unable to extract a project that is the maximum possible value-for-money from the private sector.

According to the National Treasury (2004a), the foundations of PPPs in South Africa are laid down in the National Treasury Regulation 16 to the Public Finance Management Act (PFMA) 1999. Treasury Regulation 16 was first issued in May 2000 and, subsequently, it has been continuously revised in order to take into account the PPP procurement experience being accumulated. In February 2005, 12 PPP projects have reached financial close in South Africa (National Treasury, 2005). These pieces of legislation and regulation provide a solid foundation for PPPs.

In addition, in March 2004, the National Treasury (2004d) laid down the basic contractual terms for PPPs into a document titled: *Standardised PPP Provisions*. These provisions are in effect guidelines for drafting a standard PPP contract that sets out the risk allocation between the client and the private party. In entering into a PPP contract, the client must comply with the provisions unless it can demonstrate to the National Treasury that deviating from them will improve the value-for-money of the project without shifting the balance of risk towards the public sector.

Moreover, in August 2004, the National Treasury issued a guidance document on the procurement and governance of PPPs. The document, containing nine modules, is titled: *National Treasury PPP Manual*. It sets out the various steps in great detail that the client must take in obtaining services through PPPs. The outline of these steps in illustrated in Figure 1. By February 2005, seven of the modules had been published with the publication of the two remaining modules expected in the near future.

In summary, the private parties bidding for and undertaking PPPs in South Africa are protected by legislation and regulation and can rely on established procurement and governance procedures and contractual terms. These include best practice procedures that must be followed for organising a bidding competition (National Treasury 2004c), for managing the contractual relationship with the private party over the project term (National Treasury 2004e), and for ensuring the transparency of the client’s actions (National Treasury (2004f). This reduces the uncertainty associated with the future revenues that will stem from the PPPs that the private parties are pursuing, which is likely to make them more willing to bid for the projects.

Figure 1. The PPP Project Cycle in South Africa (National Treasury, 2004a).

A reduction in the uncertainty of revenue from a PPP increases its *expected value* as it increases the certainty that the private party will receive the anticipated revenue from the project in full (event 1) and decreases the likelihoods of events (2 to n) that would compromise the anticipated revenue. The mathematical expression of expected value of the revenue is given in Formula 1.

$$R_{EV} = R_1 \times p_1 + ... + R_n \times p_n \qquad (1)$$

where, R_{EV} is the expected value of revenue from the PPP,
R_1 is the value of revenue in event 1,
p_1 is the probability of event 1,
R_n is the value of revenue in event n, and
p_n is the probability of event n.

The expected values of revenues in Formula 1 are present values discounted at the opportunity cost of capital of the private party bidding for the project. The probabilities of all possible revenues (in events 1 to n) must equal one. It must be noted that a similar expression to Formula 1 can be devised for the expected value of costs the private party will incur in undertaking a PPP. It must be noted that the expected values of revenue and cost may vary due to reasons other than government intervention such as technological innovation. However, such risks are not specific to PPPs in South Africa.

4. Intensity of Competition

According to Klemperer (2002), the economic benefits from an auction can be compromised due to inadequate level of competition, which can be caused by either inappropriate number of bidders or low quality of bidders.

A PPP can be considerable in size and complexity and in all cases client procures the PPP using an output specification. This is a specification that describes the project deliverables in terms of service outputs, rather than technical inputs which is the traditional approach within the industry. Some degree of input specification may, nevertheless, be required in all projects. The private parties develop their proposed solutions for the PPP within the constraints of the output specification (National Treasury, 2004c).

The cost that a private party will incur for developing a solution in response to the client's output specification is high when compared to the cost of bidding for traditional construction and facilities management service contracts (National Treasury, 2004c). Thus, the cost of entry to a PPP auction is high. This may deter some private parties from bidding for the PPP by building a significant barrier of entry to new entrants into the market and, thus reducing the pool of interested bidders.

In terms of the Expected Utility Theory (see e.g. Schoemaker, 1982) that sees actors either as *risk-neutral*, *risk-averse* or *risk-prone*, a risk neutral actor will only bid for a PPP if the expected value of its profit is at least equal to its bid cost. Formula 2 gives the mathematical expression of expected value of profit. The probabilities of a successful and an unsuccessful bid must equal one. If the bidder is unsuccessful in the auction, its expected revenue and cost and, thus, profit are zero. A risk-averse private party will require its expected profit to be higher than its bid cost in order to participate in a PPP auction whereas a risk-prone actor will be willing to enter the bidding competition even if its expected profit is lower than its bid cost.

$$\pi_{EV} = p_S \times (R_{EV/S} - C_{EV/S}) + p_U \times (R_{EV/U} - C_{EV/U}) \qquad (2)$$

where, π_{EV} is the expected value of profit from the PPP,
p_S is the probability of a successful bid,
$R_{EV/S}$ is the expected value of revenue of a successful bid,
$C_{EV/S}$ is the expected value of cost of undertaking the PPP if successful,
p_U is the probability of an unsuccessful bid,
$R_{EV/U}$ is the expected value of revenue of a unsuccessful bid, and
$C_{EV/U}$ is the expected value of cost of undertaking the PPP if unsuccessful.

The National Treasury (2004c) takes the view that the client should not normally compensate unsuccessful private parties for their bid costs. Thus, the private parties bid at risk and their bid costs will become sunk costs if they are not awarded the contract. However, the National Treasury (2004c) acknowledges that in cases where the cost of bidding is so high that private parties are unwilling to enter the bidding competition, the client may contemplate reimbursing the bidders with a pre-agreed percentage of their verifiable costs of compiling and submitting compliant proposals. This will reduce the bid cost in relation to the expected value of profit from the PPP and, thus, increase the likelihood that a greater number of private parties will enter the bidding competition. The National Treasury (2004c) also emphasises that the client should explore the possibility of sharing some bid costs among the private parties and, thus, decreasing the cost incurred by each bidder. An example of this would be a jointly funded ground condition survey.

The National Treasury (2004c) outlines a procedure for ensuring that the client has an appropriate number of private parties wanting to bid for the PPP. The client should advertise the project requesting expressions of interest from the private sector. At this stage, the client should have set out the basic parameters for the PPP and can use the feedback from the market to establish whether it will be able to organise an effective bidding competition for the project in its advertised configuration. If the market response indicates that there is likely to be an inadequate number of interested bidders, the client can then either abandon or re-scope the project.

Once the client has decided to proceed with PPP procurement, it should use prequalification to ensure that that an appropriate number of competent private parties are invited to bid. This should ensure an appropriate level of competition for the project. According to the National Treasury (2004c), in prequalification, the client should assess the interested private parties in relation to their technical, financial, legal and Black Economic Empowerment (BEE) capabilities. BEE is the South African Government policy that seeks to promote historically disadvantaged individuals. According to the National Treasury (2004g), a good BEE practice in PPP amounts to meeting or exceeding specific targets for equity participation, management control and subcontract award.

Under the National Treasury (2004c), at prequalification, the client should select three or four private parties to bid for the PPP. The National Treasury feels that such number of bidders will entice the highest achievable level of competition by providing the private parties with an acceptable probability of being successful given the high cost of bidding. On the one hand, if the number of bidders was to be higher, some competent bidders might be deterred from entering the competition due to low probability of success. On the other hand, if the number of bidders was to be lower, the most capable private parties would participate, but the competition would be limited due to the small number of bidders. Therefore, if the client invites too many or too few private parties to bid the intensity of the competition may be compromised.

A major problem in procuring PPP projects is that once the client has invited a number of private parties to submit proposals for the project, some of the bidders may choose to withdraw from the bidding competition – see e.g. Sader (2000). This is because it is only at this stage that the parameters for the solutions that the client is seeking are fully revealed to the bidders. As a result, the private parties are now in a position to better predict their likely success in the bidding competition. If they feel that the probability of a successful bid in not acceptable, they will abandon the pursuit of the project.

The National Treasury (2004c) recommends that the client uses bid bonds to mitigate the problem of bidder withdrawal. In other words, the client should require the prequalified private parties to deposit bonds that it will refund only if they submit compliant proposals. If a private party is unwilling to submit a bond, the client must not prequalify it to bid for the project. A bid bond should be at least equal to the cost the client would incur if it had to recommence the bidding competition (National Treasury 2004c). If a private party abandons the pursuit of the project, its bond becomes a sunk cost. However, the bond is only likely to be effective in deterring a private party from withdrawing, if it is higher than its cost of submitting a compliant proposal. If the bid bond is less than that amount, it remains advantageous for the private party to withdraw if it feels that it has no chance of becoming the preferred bidder. Therefore, the existing recommendation on the magnitude of the bid bond may be inappropriate. This is because even if the bid bond would compensate the client with the cost of restarting the bidding competition, a withdrawal due to an unsuitably low bid bond would have a negative impact on the society as it would delay the stream of benefits that flow from the project.

If the client fails to obtain its desired number of compliant proposals for the PPP, it must treat the option of procuring the project traditionally as a competing proposal. This option is known as the Public Sector Comparator (National Treasury, 2004c). The use of such a comparator may result in a number of problems due of the credibility of using traditional procurement as a genuine alternative. A traditionally procured project would have to be financed from public funds when the access to private sector finance is one of the primary reasons for the use of PPP. Thus, the credibility of such an alternative is likely to erode the bargaining power of the client. It must be noted that the National Treasury (2004c) recommends that a PPP be abandoned or re-scoped if there is no appetite for the project in the market and that the client should use bid bonds. As a result, in theory, a situation where the client does not receive its desired number of compliant proposals should not arise.

5. Negotiations with the Preferred Bidder

Once the client has selected a private party as the preferred bidder, the actor is no longer subject to competitive pressure. As a result, the private party's bargaining power in relation to the client is considerably strengthened. This is because the client cannot change the preferred bidder easily without incurring significant sunk costs. These sunk costs are the costs that the client incurs in negotiating with the preferred bidder in pursuit of the financial close of the project. Therefore, if the solution for the project requires changes outside the parameters agreed at the appointment of the preferred bidder, the private party is be able to extract a price for the changes that may exceed market prices as it is no longer in direct competition from other bidders.

In theory, the preferred bidder stage exists to allow the client and the private party to agree the outstanding finer details of the project. In addition, in project finance PPPs, the financier needs time to carry out a due diligence in order to satisfy itself that the level of risk in the project is in line with its expected returns from financing it. The negotiations and the due diligence should not affect the previously agreed details of the project (National Treasury, 2004c). However, it must be acknowledged that in practice this may not always be the case and that issues may arise, especially in the course of the financier's due diligence, that need to be agreed through negotiations, which that may compromise the value-for-money of the PPP.

A number of strategies that the client can use to ensure that the value-for-money of the PPP is not compromised in its negotiations with the preferred bidder are outlined in the documentation (National Treasury 2004c). First, the client must appoint the private party with the second-best bid as its reserve bidder. This enables the client to commence negotiations with the reserve bidder if the negotiations with the preferred bidder break down due to the private party's abuse of its monopoly position. The appointment of a reserve bidder will slightly improve the client's bargaining power, but the problem is likely to persist nevertheless.

Second, the documentation requires both the client and the private party to carry out a number of due diligences prior to being allowed to proceed to the preferred bidder stage (National Treasury 2004c). The client must carry out a first due diligence on its bid documentation before inviting the private parties to prequalify and a second due diligence before requesting them to submit proposals for the PPP. The client must carry out the due diligences in order to obtain the approvals I and IIA from the National Treasury (see Figure 1) in order to be allowed to proceed with the project.

The client undertakes its due diligences at the stage where it can only assess its proposed contractual framework (i.e. the tailored standard provisions) and boundaries for the technical solution for the project (i.e. the output specification). It is likely that these due diligences will resolve a number of issues that would have otherwise surfaced only in the due diligence carried out by the preferred bidder's financier at the preferred bidder stage.

In addition, the National Treasury (2004c) requires all the bidders to carry out a due diligence on their proposals before submitting them. If the private party with the most economically advantageous bid cannot demonstrate that it has undertaken the assessment, the client will be unable to obtain approval IIB from the National Treasury (see Figure 1) that it requires in order to nominate the preferred bidder. This is likely to decrease the likelihood of problems arising in the preferred bidder stage and, thus, compromise negotiations between the client and the private party. It must be noted that the requiring all the bidders to undertake a due diligence on their proposals will increase their bid costs, which might potentially deter them from entering the competition.

It must be noted that neither the client's nor the private party's due diligences early in the procurement process will remove the financier's need to carry out a due diligence in the preferred bidder stage. However, the financier will be able to draw on the assessments already undertaken and, thus, speed up the process. Nevertheless, it is possible that in the financier's due diligence previously undetected issues arise that need to be resolved through negotiation. Therefore, it is not known whether the erosion of value-for-money prevented by the stringent requirement to carry out due diligences early on in the process will be greater than the potentially lost value-for-money as a result of a possible reduction in competitive pressure caused by increased bid costs.

Once the client has agreed the detailed contractual terms and technical solution for the project with the preferred bidder, it must apply for approval III from the National Treasury (see Figure 1), which enables it to proceed to award the PPP contract (National Treasury, 2004c).

6. Collusion and Predatory Behaviour

Klemperer (2002) highlights collusion and/or predatory behaviour as major problems in organising effective bidding competitions. In other words, two or more bidders my act together in order extract a high price from the client for undertaking PPP or one of the bidders may abuse its market power in order to prevent the other bidders from submitting genuinely competitive proposals. Such practices are like to compromise the value-for-money of the project.

PPP procurement must comply with the Competition Act 1999 (National Treasury 2004c). The main purpose of the act is to foster competition within South Africa in order to increase the global competitiveness of the nation. In terms of the Competition Act, the South African Competition Commission may intervene to prevent collusion and/or predatory behaviour in procurement if, for example:

- collusion between two private parties limits competition,

- collusion between the actors of a private party limits the ability of the other bidders to compete for the project,
- a private party abuses its market dominance by, for example, undercutting the prices of other bidders in order to prevent them from obtaining a toehold and, thus, building a track-record in the PPP market, and
- actors that are either part of the same private party or different private parties merge thereby limiting competition

Under the National Treasury (2004c) guidance, the client should be proactive and seek to identify anti-competitive collusion and/or predatory behaviour that may be encountered during its procurement process and devise strategies for dealing with the identified situations as they arise.

In addition, the National Treasury (2004c) requires the client to give consent to a change of an actor in a private party in the course of the procurement process. The client should only allow such change if it increases the strength of the private party against its prequalification criteria. The ability to withhold consent is a powerful tool for the client to prevent collusion and/or predatory behaviour. However, it must be noted that it is also possible that if the client were to withhold its consent on a change of a consortium member, it might cause a private party to abandon the bidding competition with adverse consequences on the level of competition.

7. Conclusions

The legislative and regulatory framework and the associated guidance documentation used to govern PPPs over their project cycles in South Africa appear to foster competition. If public sector clients successfully implement all the prescribed measures on actual projects they are likely to result in improved value-for-money projects. There are, however, a number of issues inherent in the guidance documentation that require further investigation, such as whether the current recommendation on the magnitude of bid bonds is appropriate and whether the requirement for private parties to carry out a due diligence before being appointed the preferred bidder increases bid costs to the extent that it deters some of them from entering the bidding competition. In addition, it is not know how the procedures are implemented in practice. Thus, further research is also required in order to establish whether clients can translate the existing procedures for procuring and governing PPPs to value-for-money projects.

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Regulating Professions: Shifts in Codes of Conduct

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Abstract

Professional institutions were established by professionals, for professionals. The way that these professions evolved has led to a need for them to regulate themselves. This has resulted in the development of codes of conduct to which members must adhere, under threat of expulsion. Since these professions were established, the definition of 'consumer' or 'client' has changed radically. This has lead to discrepancies between self-regulation and imposed government regulatory measures. Clients rely on professionals having a code of conduct to protect their interests, however these codes are under attack as they are often considered to be anti-competitive. Government is influencing the way these organisations conduct themselves, as is clear from changes in the profession's codes of conduct over the last two decades.

Keywords: self-regulation, consumer, client, professional, competition.

1. Introduction

1.1 Overview

The development of the professions is an interesting but complex story. In the UK, many of the construction professions were created by entrepreneurial adventurers who forged new techniques and ways of working, and developed distinctive bodies of knowledge [1]. As the technologies involved were inherently dangerous, practitioners adopted models of self-regulation based on those of the existing medical professions, as well as the mutual cooperation model of the guilds. Practitioners felt the need to protect themselves from charlatans who would not only work more cheaply, but also bring the field into disrepute. Thus professional self-regulation is a two-edged phenomenon: public protection and protection of the profession [2].

Apart from regulating entry into the profession, the primary form of self-regulation for architects has been the publication of codes of professional behaviour. The idea behind this is that any member who behaves unprofessionally may be barred from practicing.

1.2 International relevance

UK government takes an 'ad hoc' approach to regulating the professions, in contrast to many European countries, where the regulation of professions is treated more systematically. Due to its unique history, the UK avoided the Napoleonic legal reforms which swept through the Continent in the early 19th century. As a result, the UK retained its political system intact since 1688, despite significant social and electoral reforms, whereas many European political systems have their origins in the 20th century.

In the UK, the status of many professions was formalised in the first half of the 19th century via the grant of royal charters to self-regulating institutes. For example, the Royal Institute of British Architects (RIBA) was established in 1834. After a period of self-regulation, the government introduced a regulatory body called the Architects' Registration Council of the United Kingdom (ARCUK) in 1931, which was replaced by the Architects' Registration Board (ARB) in 1997.

Paradoxically, while the title 'architect' is protected under UK law, there is no restriction on carrying out the functions of an architect. Thus individuals who are trained and registered as architects are subject to professional regulation. In contrast the unqualified may practice architecture subject only to the general law, as long as they do not call themselves architects.

While the RIBA does not currently have a statutory role, it functions as a professional society dedicated to advancing the cause of good architecture, as well as promoting architectural education and good practice. The RIBA is a self-regulating body, and its members must adhere to the RIBA Code of Professional Conduct, which has been subject to many revisions in the past 25 years.

This research is concerned with examining whether such a code is responsive to changes in the wider business, economic and legislative environment. The purpose of this ongoing PhD research is to track the significant changes to the RIBA code of conduct since the 1981 edition of the RIBA Code of Professional Conduct and Standard of Professional Performance, and identify the drivers of these changes.

The importance of this research is to trace whether these changes are responses to commercial or to regulatory pressures. For society at large, in other words, this raises the important question of whether professional codes of conduct focus on the public good, or on institutional survival, or a mixture of the two. This question has been debated within the RIBA and other construction professions since at least the 1970s [3] and continues to be topical. Even today, there are serious questions about the future of the professions in the construction sector [4].

1.3 Regulatory background

Article 81 of the Treaty establishing the European Community (EC) prohibits agreements or decisions by participants within a market sector 'which have as their object or effect the prevention, restriction or distortion of competition' [5]. Subsequent legislation has created more effective mechanisms for enforcing Article 81 within the UK. 'Since 1 May 2004 not only the European Commission, but also the Office of Fair Trading (OFT) has the power to apply and enforce Articles 81 and 82 of the EC Treaty in the United Kingdom' [6].

In 2000 in the UK, the Office of Fair Trading began conducting investigations into professions whose services constitute a significant portion of the economy. Such professions as accountancy, law and architecture fell into this category, while teaching and the medical professions were excluded [7]. The purpose of their investigation was to reveal whether the selected professions were carrying out practices deemed anti-competitive.

Perceived restrictions on competition targeted by the OFT included limitations on entry, demarcation, and conduct. The OFT's stated position was that '(a)part from those shown to be necessary for economic efficiency and consumer benefits, restrictions on competition should go' [8]. This portion of the research will focus on those restrictions which fall under the heading 'conduct,' including fixed and recommended fee scales and advertising.

The OFT's investigation brings to light the relationship which the client/consumer is meant to have with the professional. The OFT acknowledges that a high quality service is inherently supplied by a person who is qualified, which is the traditional basis of professional practice. However, they advance the thesis that a consumer and a client are one and the same, which marks a new departure in the history of the client-professional relationship. In deregulating the professions, the OFT is pursuing a consumer-centred agenda. This is reflected in the dual mandate of the Architects Registration Board (ARB), a statutory body set up in 1997: "Protecting the consumer and safeguarding the reputation of architects" [7]. The precursor to the ARB had itself been under threat, as the legislation concerning the protection of the term "architect" had been under threat for some time [9].

The frequent changes and amendments to the RIBA Code of Conduct since 1981 are a reflection of the forgoing influences and form the subject of this study. It is interesting to see how the profession has responded to these pressures, and it seems safe to assume that formal responses to perceived changes in the business environment of architects will be reflected in the way that a code of conduct is revised and amended. Thus, it is proposed to track the RIBA's response to the enforced deregulation of the profession through content analysis of successive editions of the code of conduct, to examine whether substantive changes are reflected by changes in vocabulary or scope of the code of conduct.

The RIBA has generally responded by complying with the OFT's requirements, deleting or amending clauses of the code, whilst resisting wholesale changes. However, January 2005 marked the publication of a completely rewritten Code. This research is intended to track both of these responses to the deregulation of the profession through content analysis. Content analysis is a research technique that is designed to elicit meaning and context from documents. The purpose is to examine the words and the meanings with documents, and in order to do this data collection consists of identifying the presence, frequency, prominence, direction and intensity of particular ideas, words or phrases [10].

1.4 Research method

Based on the history and sociology of the key professions in the UK, the evolution of codes of practice are contextualised, with particular reference to advertising, property development, fee discounts/competition, professional indemnity insurance, client expectations, business exigencies for the practice, etc.

By using the content analysis methods of word frequency count and keyword-in-context, this research is an attempt to track changes in the RIBA Code of Conduct between 1981 and 2005. It is anticipated that patterns will emerge reflecting overall trends in professional regulation as well as shifts in professional practice.

2. Codes of conduct from 1981-2005 (total word and significant word count)

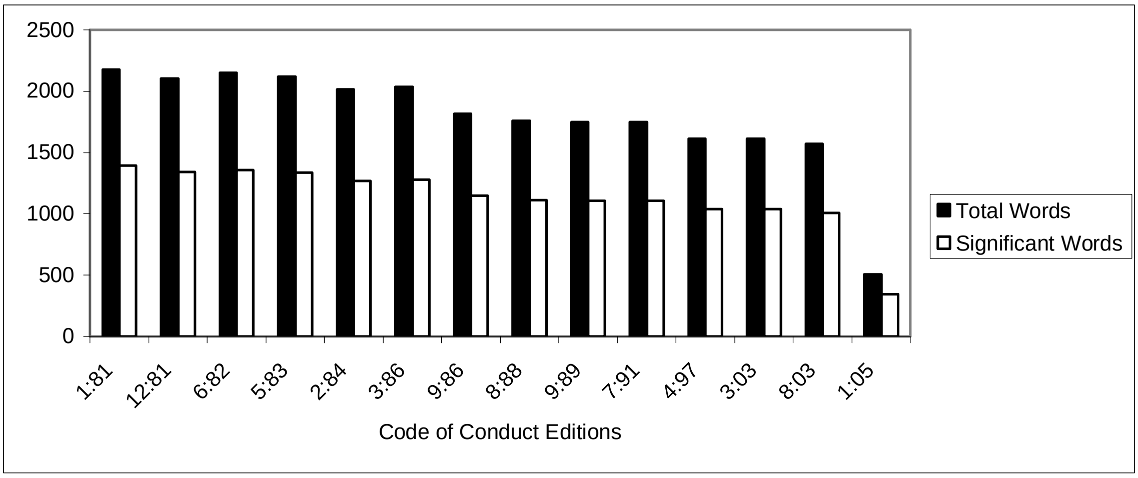

Figure 1: Numbers of words in successive editions of RIBA Code of Conduct

2.1 Methodology

The first part of the research entails mapping out the RIBA Codes of Conduct from 1981 to 2005 to observe how the content of the Codes have changed over the last twenty years. The objective is to see if there are any patterns that emerge out of the alterations in content within this timeframe. Figure 1 indicates a full word count of the contents from 1981 to 2005. The content of the Codes during this period have been edited to include only those words deemed significant for the study. Table 1 shows which words were excluded from the total word count in arriving at the significant word count.

Table 1: Words excluded from the significant word count

a	be	doing	in	so
an	been	done	into	that
and	before	for	is	the
any	being	from	made	to
are	by	has	make	with
as	do	have	of	
at	does	having	on	

2.2 Observations

Based on Figure 1, the following observations can be made:

- word pattern and count is fairly consistent from January 1981 until June 1991.
- word pattern dramatically changes in April 1997, but remain constant in the subsequent 2003 editions.
- there is a another dramatic shift in word pattern in the January 2005 edition, where word count dramatically drops.

It is apparent in Figure 1 that there is a sharp decrease in the word count from the 2003 edition to the 2005 edition, which indicates a major alteration to the content of the Code during those periods. This signifies a concerted effort to rewrite, not merely amend, since edits and simple revisions may usually be expected to cause only minor variations in document length.

3. Specific keywords

3.1 Methodology

In Figure 2, specific keywords in the research are counted within each of the Code editions. These words have been selected as they relate to the portions of the code that have previously been under question by government, such as the responsibilities of the professional to the public. Part of the investigation is to determine if their meaning and use has changed over time, or to see if their use has diminished.

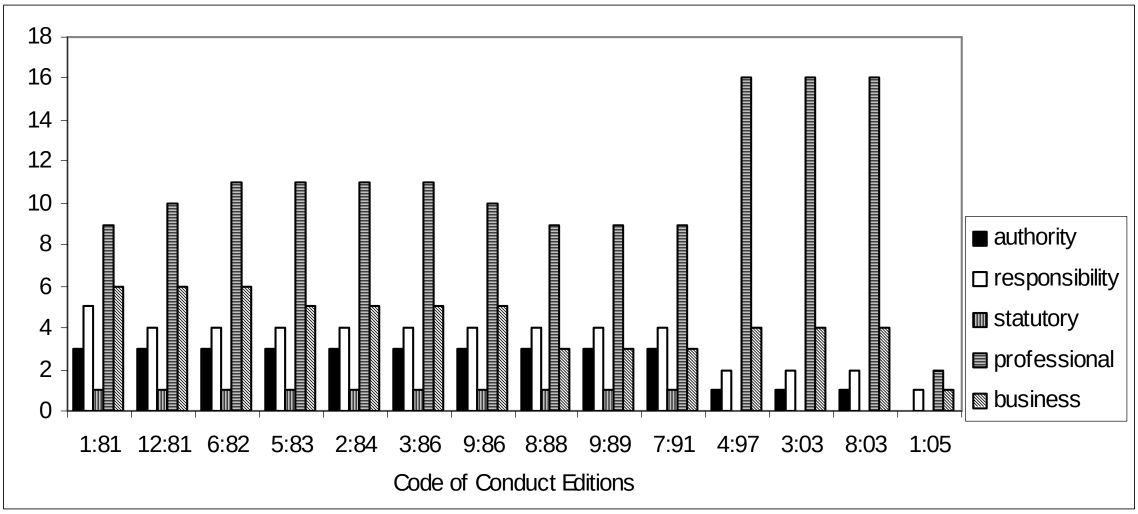

Figure 2: Number of oFigure 4: Example of mapping technique, illustrating changes to Principle No. 3

Words have been selected for analysis that are expected to form part of the a meaningful message to members of the profession with references to:

- services provided to the client
- issues of professional integrity
- corporate (acting as a single body) as opposed to competitive behaviour

Potential conflicts between these categories are addressed at certain points in the various editions of the code of conduct. This particular avenue will be explored further in future research.

3.2 Observations

Based on Figure 2, the following observations on specific word count and pattern of use from 1981 to 2005 editions may be made:

- § the word count pattern is consistent in that there is a reduction in the use of terms from the January 1982 edition through to the January 2005 edition.

- § the word 'professional', whose use jumps dramatically from the April 1997 to the August 2003 edition, is an exception to the trend noted above. 'Professional' is then dropped completely in the January 2005 edition.

- § the word 'authority' is dropped entirely in the January 2005 edition.

Comparing the overall word count in Figure 1 and the specific keyword count in Figure 2, some specific keywords follow the trend discernable in the overall word count, while others follow their own pattern. For example, the specific keywords 'authority' and 'responsibility' follow the trend of the overall word count, whereas 'professional' has its own distinctive pattern.

4. Keywords in context

4.1 Methodology

Although word count is used as a method of analysis, further validation of results is necessary to indicate the use of the word in context and to identify distinctions of meaning. In Section 3, specific words were counted and observed. However, there are other specific words that occur which have alternate meanings depending on their context. The table in Figure 3 indicates examples of alternate meanings identifying the edition and the precise context in which the specific word is used.

4.2 Observations

As indicated in Figure 3, the word 'competition' is used in the contexts: 'architectural competition', 'competition between members' and 'any form of competition.' In note 2.9.6 of the January 1981 edition, "architectural competition" refers to a formal process where architects are invited to submit design solutions to a defined brief in order to win an award. In note 3.2.2 of the same edition, "competition with other members" refers to a member's behaviour. It is considered 'unprofessional' for members to compete with each other on the basis of price or by questioning the reputation of another member.

COMPETITION	
January 1981 Edition	
note 2.9.6	An employing architect should permit the architects he employs to enter **architectural competitions** but they should not do so without the knowledge of their employer
note 3.2.2	It would be contrary to this Rule for a member to submit estimates of fees and expenses knowing that they would be used for the purpose of **competition with other members**.
January 2005 Edition	
RULE 2.2	Where members are engaged in **any form of competition** to win work or awards, they should act fairly and honestly with potential clients and competitors. Any competition process in which they are participating must be known to be reasonable, transparent and impartial. If members find this not to be the case, they should rectify the competition process or withdraw.

Figure 3: Example of key word in context

In rule 2.2 of the January 2005 edition, the term "competition" is used to refer to both a competition to enter into and competition among members for work. Thus, the word 'competition' has two different meanings in different contexts in the January 1981 edition, whereas in the January 2005 edition, it is used with both meanings in the same context.

Specific keywords may have different meanings attributed to them by regulatory bodies. For example, the Monopolies and Mergers Commission, a UK regulatory body, have investigated what they deem as "anti-competitive" behaviour in the professions, resulting in the eradication of fee scales [10]. The discrepancy in the use of specific words such as 'competition' by the profession and by regulatory bodies will be investigated in further research.

5. Code breakdown: principles, rules and notes

5.1 Methodology

The Code is broken down in Principles, which are further broken down into Rules and Notes. The table in Figure 4 is used to distinguish between types of amendment by means of graphical notation.

5.2 Observations

Each of the categories from the 1981 to the 2005 editions of the Code was tracked, as indicated in Figure 4. From 1981 to 1991 the majority of content appears to have remained unchanged. The following types of change in content were noted:

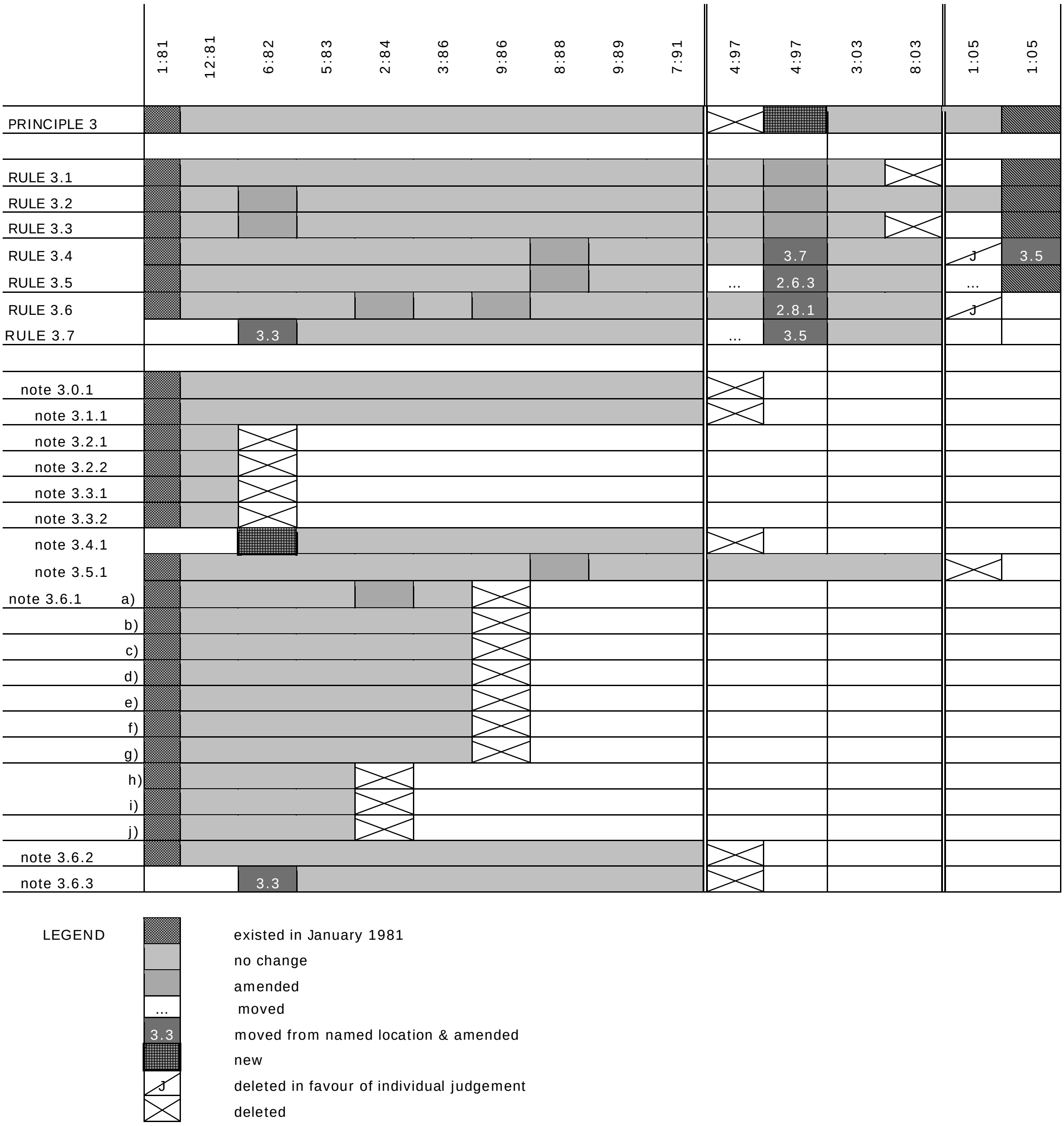

Figure 4: Example of mapping technique, illustrating changes to Principle No. 3

- content is unaltered (remains unchanged)

- amendments:
    - § content re-used, with slight amendments, maintaining original meaning
    - § content re-used, with amendments, altering original meaning
    - § re-written with an altered meaning
- moved as a result of ‘reshuffling’ but maintaining original content
- moved and amended
- deletions
- additions

The instances of major change in editions of the Code become apparent between the 1991 and the 1997 edition and then again in the 2005 edition, where the content is almost completely altered. Deletions appear to be particularly meaningful because it appears that the professional institution has responded to government demands primarily by ‘striking out’ content. Figure 4 illustrates the evolution of Principle no. 3, by way of example. There are also several instances of compulsory rules being replaced by a requirement to exercise professional judgement. This may indicate a more proactive approach to self-regulation, centred on the individual practitioner.

6. Conclusions

A review of the RIBA Codes of Conduct from 1981 through to 2005 has revealed a number of fundamental themes relating to professional regulation:

In the research carried out thus far, instances of deletions seem to be particularly meaningful because it appears that from 1981 to 1997 the professional institution has responded to government demands primarily by ‘striking out’ content. This appears to indicate a policy of minimum compliance to regulatory pressures.

The concept of ‘competition’ in particular is central to understanding the conflict between the interests of the profession, as represented by the RIBA, and the interests of the public, as advocated by the Office of Fair Trade. Thus the word ‘competition’ takes on various meanings in the editions of the Code of Conduct, in the context of the removal of competitive barriers.

Finally, in 2005 a re-written version of the RIBA Code of Conduct has addressed the deregulation of the profession by replacing mandatory rules with the use of professional judgement. This is a more pro-active approach to the regulatory pressure than the previously mentioned strategy of deletion.

Thus the methodologies of word count, keyword in context and a study of the categories of changes to the code appear to offer a promising direction in further research.

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Factors Affecting the Selection of Building Contract Payment Systems

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Abstract

The selection and development of an appropriate project cash-flow model can promote the Egan principles of integration and early project based planning. This is a fundamental concept behind a research project that aims to encourage the use of appropriate innovative payment systems in the UK building industry. The project, which is funded by the Engineering and Physical Science Research Council (EPSRC), investigates the potential advantages of using payment systems by linking them to project characteristics and performance. This paper identifies the alternative payment mechanisms available for use in the building industry; and investigates whether practitioners are providing appropriate advice to their clients on the selection of appropriate payment systems for their projects. The paper then considers data gathered through direct interaction with practitioners so as to explore current practice on the ground. This contact was iterative in its nature and this process was continued into the next stage of the project through the use of conference type discussions. The preliminary finding from this phase of data collection and analysis is that the payment system selection process itself lacks coherence and consistency. This lack of consistency in practice suggests an ad-hoc approach to the selection of payment systems, which could be a constraint on the delivery of post Egan change in practice. This interim finding reinforces the case for the research and the paper concludes by outlining the next phases of activity.

Keywords: building industry, cash-flow, Egan principles, payment system.

1. Introduction

For what can be regarded as a very long time now, the construction industry has been shown to be inefficient and unproductive which has been made more obvious by the success of other industries, such as manufacturing, that are sometimes using similar approaches. The Latham Report (Latham 1994) [1], for example has highlighted inadequacies in contracting *per se* whilst the Egan Report (Egan 1998) [2] featured major clients who are not happy with the traditional methods. The construction industry has been recognised as a financially higher risk industry (Ruddock, 1996) [3]. The nature of the industry is such that generally the project construction team prefinances the project and then relies on being reimbursed for the works to progress diligently. Unfortunately though, many main contractors have faced severe financial difficulties when their source of cash flow to execute contracts slows down, and even in some cases, ceases altogether. Subcontractors and suppliers are often at the mercy of their main contractors who sometimes refuse to release their payments accordingly. The lack of money in the industry is made worse by the lack of trust amongst supply chain players.

It is thus paramount that the industry moves away from the non productive approaches it has been renowned for in the past. This should include establishing effective means of ensuring cash flows to the entire project construction team. This research project believes that payment systems can assist the building industry to be more efficient and productive. There are novel alternative payment systems that are effective contract management approaches. The issues raised in this paper can be a source of encouragement to clients and their advisers to endeavour in designing and choosing the appropriate payment systems for their projects so as to achieve better success in project delivery.

The paper starts by referring to literature review noting the pricing and payment systems in use in the global building industry and the forms of contracts in which they are applicable. This is then followed by consideration of the data from the interview survey focussing on the systems in use in the UK and the factors that influence practitioners' choices. Each of the eight most common factors is then discussed.

2. Pricing, payment and contracting systems

A study by Njie *et al.* (2005) [4] reviews relevant literature and identifies several pricing and payment systems used in the global building industry. These systems are illustrated in **Figure 1** with five systems categorised under payment systems exclusively for payment only and eight others under pricing systems for both pricing and payment. This research project assumes payment systems to refer to the approach in which building products and services are priced and paid for.

Standard forms of contracts for building works often require the client to make periodic payment of the agreed contract sum to the contractor. It is the principles behind these contracts with regard to their pricing/tender and payment procedures that this study is based on. **Table 1** from Njie *et al.* (2005) [4] illustrates the most common standard forms of building contracts with their associated existing payment systems. The novel payment systems such as the stage payments, incentive contracting, direct payment, trust accounts/funds, mobilisation advance payment and the mechanic's lien can be used with any contracting system. Standard forms for civil engineering projects, notably the ICE and FIDIC, use the same payment systems as their corresponding JCT contracts.

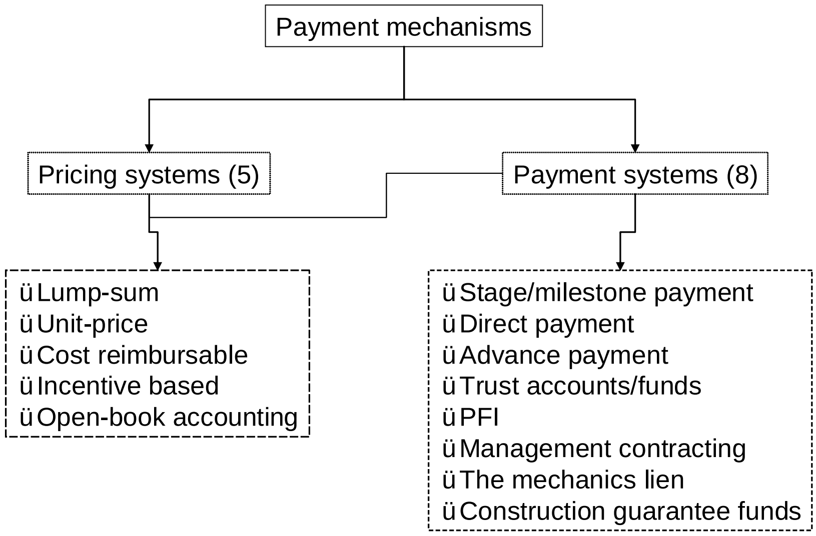

Figure 1 - *payment mechanisms identified from the literature*

Table 1 - the most common building contracts with their associated payment systems

	Building contracts	Lump-sum	Unit-price	Cost-plus-percentage-of cost	Guaranteed maximum cost	Novel payment systems
	JCT 98 Standard Forms					
	Private or Local Authority					√
1	with quantities		√			√
2	without quantities	√				√
3	with appro. quantities		√			√
4	with contractor's design	√			√	√
5	IFC 98 Intermediate Form	√	√			√
6	MTC 98 Measured term		√			√
7	MC 98 Man. contract				√	√
8	CM 02 Construction Man.					√
9	PCC 98 Prime Cost	√				√
10	GCWks1 Edition 3		√			√
11	NEC	√	√	√	√	√

3. The interview survey

The first phase of the research project started with a comprehensive review of the relevant literature on issues concerning the payment systems in use in the building industry in the UK as well as elsewhere. This was followed by data collection through direct interaction with practitioners so as to explore current practice on the ground. This contact was iterative in its nature and structured interviews with six questions were carried out with eight practitioners whose businesses were located in both Scotland and England. The professional backgrounds of the interviewees were: consultant quantity surveyors-5 number, architect-1 number, building services subcontractor-1 number and PFI project company-1 number. A short description of each of the eight companies interviewed is made as follows: Pilot Company, and Companies V, Y and Z are leading consultancy firms operating worldwide providing cost and risk advice; Company T is a project company that was set up to work exclusively on PFI projects; Company U is a regional consultancy firm providing cost and risk advice; Company W is a building services subcontractor; and Company X is a regional consultancy firm providing architectural and design advice for predominantly housing association work. The sample of firms for the interviews was primarily provided by members of the project steering group. The intention was to provide a good mix of practitioners in both Scotland and England. The sample is however, not necessarily a structured, representative sample of the UK building industry. Only two of the six questions are considered in this paper.

3.1 Pricing and payment systems in use

Table 2 shows that the traditional pricing and payment systems of the unit-price and lump-sum remain the most frequently used systems by six out of the eight companies interviewed. The two other systems that are the first choice to these companies are the stage payment and the PFI payment mechanism. Others, such as direct payment, mobilisation advance payment, cost-reimbursables and trust accounts/funds are used, in that order, as alternatives with trust accounts/funds also as the system most said to be not in use. Whilst the incentives, management contracting payment mechanism, construction guarantee funds and the mechanic's lien are not used at all.

Table 2 - *the pricing and payment systems in use*

Item ref.	Company	Most Used	Others Used	Not Used
1	Pilot Company	b	a, c, f and j	d, e and h
2	Company Z	d	many incl. f, a and b	g
3	Company Y	b	a, c, d, g, and h	-
4	Company X	b	a	c, g and h
5	Company W	a	b	c, d and h
6	Company V	a	d, b, f and h	c and g
7	Company U	b	f, a and h	g and k
8	Company T	j	f and h	d and g

Key:

a. Payment requests for lump-sum contracts
b. Payment requests for unit-price contracts
c. Payment requests for cost-reimbursable contracts
d. Stage payment (also the pre-agreed cash flow, s-curve or drawdown schedule)
e. Incentive contracts
f. Direct payment
g. Payments from trust accounts/funds
h. 'Client financed construction' procedure/mobilisation advance payment

i. **Construction guarantee funds**

j. **Private Finance Initiative (PFI)/Public Private Partnership (PPP)**

k. **The mechanic's lien**

l. **Management contracting**

3.2 Factors for choosing payment systems

The eight companies interviewed consider nineteen factors when choosing payment systems with eight of these factors being considered by at least two companies. These eight factors are procurement (Companies U, V, Z and Pilot); risk (Companies V, W, Y and Z); project characteristics/circumstances (Companies U, V and Y); project duration (Companies V and Pilot); project complexity (Companies W and Pilot); project stakeholders (Companies Y and Z); client's requirements (Companies U and Y); and client's experience (Companies V and Z). The eight factors are put in three clusters (see Figure 2) i.e. procurement and risk as the most considered - that is by four companies. Followed by Project characteristics/circumstances which is considered by three companies. And then the remaining five factors which are considered by two companies.

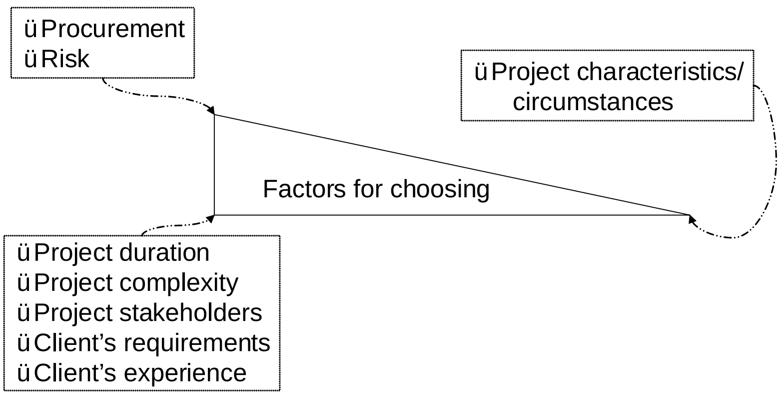

Figure 2 – *the common factors for choosing a payment system*

4. Discussions

4.1 Pricing and payment systems in use

The companies interviewed demonstrate different perceptions of pricing and payment systems. For instance, Pilot Company appears to regard any payment method that does not allow monthly payment as inappropriate and paying monthly in arrears as a payment method. Paying monthly should, however, be seen as a feature of a payment system to indicate the payment interval or period. Company Y seems to regard the traditional pricing and payment method as any method base on valuation of actual work done. This to them only includes the unit price and lump sum methods and excludes payments base on monthly pre-agreed cash flow, s-curve. Company V also seems to misunderstand issues concerning payment systems by focussing mainly on the payment period.

The companies who are fully engaged in decisions on payment systems get involved at the strategic end of the project when clients are making decisions on procurement and contracting issues. The majority of the eight companies interviewed simply use the payment terms and systems within the client's chosen contract and/or procurement strategy. Perhaps the use in the UK of the traditional procurement method (i.e. the lump sum), as shown in a survey by the RICS Construction Faculty (2003) [5], suggests why the traditional payment methods are also still the first choice.

Some of the companies have showed resistance to using alternatives to traditional payment methods such as stage payments. This suggests that adherence to routine is seen as a way of avoiding another risk that is to be managed. This is a human/social issue rather than a technical issue. The lack of use of alternatives also suggests that the durability of professional roles is preventing experimentation with payment systems. Another interesting observation is that the authority of partners is critical in the choice of payment system to use. Decisions and preferences on payment terms and systems used seem to depend on the partner-in-charge. As is the case with Companies Y and Z and also with Pilot Company and Company V, partners in the same organisation are using different payment systems. This suggests that such organisations are ready to be flexible and are not acting as champions for any particular payment system.

4.2 Factors for choosing payment systems

Construction contracts normally stipulate that the client makes part payments of the contract sum to the main contractor as the work progresses. As indicated by Harvey & Ashworth (1993) [6], it is unusual, except possibly with the smallest of projects, for the whole work to be completed before any payment is made. The procedure followed depends very much on the position of the client and the type of construction involved. The eight companies interviewed consider several factors when choosing payment systems the most common of which are discussed below.

4.2.1 Procurement

It is vital to accomplishing project success to ensure that at an early stage special care is taken in selecting the most suitable organisation for the design and construction process. This organisational concept is referred to by Masterman (2002) [7] as the "procurement system" defined as the organisational structure adopted by the client for the implementation, and at times eventual operation, of a project. Procurement is an approach used by an industry to organise itself to execute projects. Building procurement is about the practical manner clients who want to build proceed to obtain that building. Most potential clients of the construction industry have to cope with a variety of complex skills and resources that are necessary to produce the building to accomplish their needs. It is only the simplest of buildings that do not demand the management, design, assembly and commissioning of large quantities of raw materials and the use of significant labour resources over a long period of time. The completed building is the end product of the integration of the diverse skills of the entire members of the professional and physical construction project team including the client. All those involve collaborate closely to deliver the required result to the specified quality and value for money.

Company V cites as example, the choice of a procurement route, such as construction management by major repeat airport clients who have the set up to handle large sums of money a month and the volume of certification and paper processing that go with it. This is not the case for the smaller provincial airport client who has limited number of personnel. So the overriding factor to Company V is not to design a payment system but to choose a route which is more applicable or manageable to a client.

4.2.2 Risk

As reiterated by Flanagan & Norman (1993) [8], the construction industry is exposed to more risk and uncertainty than perhaps any other industry. The construction industry is different from other industries in many ways such as: its traditional processes of delivering projects, temporary project teams, adversarial attitudes, bespoke products, unique site and ground conditions, and complex contractual arrangements. It is these differences which make up the distinguishing characteristics of the construction industry and why it is regarded by many as unique.

There are all sorts of risks arising from both the internal and external environment of a project or organisation and affecting the project performance in terms of successful delivery of project success factors such as completion of time, within budget and of the specified performance. There are contractual implications that emanate from these consequences. It is thus vital that the client and project teams possibly led by a professional project manager consider the risk factors adequately and early enough to avoid their occurrence which could have damaging effects on the project and its performance. The client's approach to risk management is important, for example, as noted by Company T, to eliminate the risk of it overpaying the contractor such that it will be able to step in to complete the works if the contractor was to go burst. Also, the selection and use of an advance payment method to carry out work (which is basically a client financing approach to provide funds to the contractor before they are due) is quite risky, and therefore it is necessary to find ways and means of mitigating such risks (Abeysekera, 2002) [9]. The importance of risk management is further emphasised by Pilot Company who recognises that the chosen procurement route depends on how much risk is shared in the project and how much risk is allocated to the contractor.

4.2.3 Project characteristics/circumstances

There are many variables that make up a project's characteristics such as building type, building size, project complexity, project duration, one-off nature and the composition of the supply chain including specialists work's subcontractors. All these will have significant impact on the procurement and contractual options including their pricing and payment terms. As clients become ever more sophisticated, knowledgeable and demanding and projects become ever more complex and difficult, there is greater pressure on the client's professional advisers to choose the most appropriate options to ensure success in project delivery. As such, Company Y, for example, would design a payment system that assists the contractor if it is a large project that requires a large amount of plant to be brought to site before any site activity starts. However, they only provide assistance, such as advance payments, where the contractor needs it. Also, in some types of construction, such as housing, specified payments are made at the completion of particular stages of the project or at defined points of progress, such as at completion of excavation and foundation, at completion of framing to enclose the structure, at installation of mechanical and electrical rough-in, at completion of the interior finish, and at full completion. A payment system should be unique to the project circumstances.

4.2.4 Project duration

Although a variable of project characteristics, project duration has been found important enough to be treated separately. It is one of those client's requirements whose achievement indicates project success (Chinyio *et al.*, 1998 [10], Cornick & Mather, 1999 [11] and Winch, 2002 [12]). It would also affect the choice of payment system. If the client regards time of completion as of great essence, the contract can include provisions for the contractor to receive, on top of the base fee, a fixed amount of money for each day of useful occupancy gained by the client prior to the originally agreed-on completion date. This provision can be extended such that the contractor's fee can be reduced by the same sum for each day completion is delayed. There are a number of incentivasation and disincentivisation provisions used in the construction industry as identified by Bubshait (2003) [13] and Arditi & Yasamis (1998) [14].

4.2.5 Project complexity

Although a variable of project characteristics, project complexity, like project duration, has been found important enough to be treated separately. Decision makers should factor it in their decision-making process. For example, the lump-sum type of contract, according to Clough & Sears (1994) [15], is popular with clients for the obvious reason that the total cost of the project is known in advance. Nonetheless, its use is limited, of necessity, to construction projects that can be accurately and fully described at the tender or negotiation stage. As a result, they are generally used for residential and building construction. If it is not possible to accurately determine the nature and quantity of the work prior to the start of site activities, then the lump-sum type of contract with its inherent payment terms is not suitable.

4.2.6 Project stakeholders

The influences of the project stakeholders along with uncertainty are two factors, in particular, maintained by Kolltveit & Grønhaug (2004) [16] to affect project performance. Several stakeholders can be involved in a major and complex project. The internal stakeholders, such as the project client, project sponsor, project manager and other members of the supply chain, are individuals and/or organisations involved in the project activities. The external stakeholders, such as the community in which the project is being built and pressure groups, for example, environmentalists, are individuals and/or organisations who may be affected by the project activities. The external stakeholders, and maybe even some members of the internal stakeholders, have their own expectations which may not be compatible to the corporate project objectives. It is thus vital to recognise the influence each of these stakeholders are exerting, or trying to exert, on the project so as to sensitise them adequately and to benefit from the payment system that is selected.

4.2.7 Client's requirements

As put by Company Z, the client's objectives - delivering what the client actually needs - is the main and most important driver in anything. For example, if the client requires that he does not pay for QS fees for the valuation exercise, Company Y would set up a system where the contractor bills the client and then point out to the client the risk of doing this for the client to find a balance. Also, although Company U tends to pay at monthly intervals, it also considers the client's need to adjust the payment intervals to suit the client and then incorporate it in the tender/contract documents. It maybe that the client's requirements and the circumstances of the project, for example, are that the client has to spend a sum of money by a certain time, say at the end of the financial year. This may then influence the procurement route chosen, for example, to use two-stage tendering to speed up the process of getting the contractor to site so that the client can make payment to meet the deadline and release the money at a certain date. Every project should be looked on its own merit.

4.2.8 Client's experience

The bigger and more experienced clients, unlike the one-off clients, have their own preferred protocols which involves specific project pricing and payment options. The client may have preferred payment terms, for example, not to have a retention system on partnering projects because of the trust and long standing relationship over a period of a framework between the contracting parties. The experienced clients like the United Kingdom Ministry of Defence can invest in developing payment processes that are efficient enough to be applied across their projects. The choice of payment system would therefore depend on the client's experience in managing projects.

5. Conclusions

The unit-price and lump sum (traditional) payment systems are still mostly used and are said to be satisfactory. There is resistance to using alternatives to traditional payment methods such as stage payments, incentives, direct and advance payments which suggests routines as a way of avoiding another risk that is to be managed. This is a human/social issue rather than a technical issue. The lack of use of alternatives also suggests that the durability of conventional professional roles is preventing experimentation with payment systems. This was the case with procurement systems sometime ago - so change will take sometime to implement. Another interesting observation is that the authority of partners is critical in the choice of payment system to use. Decisions and preferences on payment terms and systems used seem to depend on the partner-in-charge. Partners in the same organisation are using different payment systems. This suggests that such organisations are ready to be flexible and are not acting as champions for any particular payment system.

The common factors that are considered when choosing payment systems are grouped in this order: procurement and risk; project characteristics/circumstances; and project duration, project complexity, project stakeholders, client's requirements and client's experience. A closer look at these eight factors suggests that at least some of these companies are deciding on payment systems that are project focused. For instance, decisions are made based on the desired objectives to be achieved and separate considerations are made depending on whether it is for stage payments or for different procurement routes such as PFI and partnering. Nonetheless, although, the companies identified these eight factors, they have also made it clear that when it comes to making the actual decision it is the client's requirement and what is contained in the chosen contract that matters. They base their decisions on payment terms and systems on what is contained in the chosen standard form of contract or what suits the preferred procurement system or client protocol i.e. what a particular client normally uses or prescribes. The systems (contracting, procurement and payment) that the clients and consultants are using are the ones they are comfortable and happy with. Clients are not asking for advice on payment systems and decide on payment terms and systems prior to appointment of professional consultants who only adopt systems prescribed by clients and tend not to offer any advice.

Despite some of the companies seeming to have some form of strategy in place for deciding on payment terms/systems, on the whole, due to lack of any consistency, it is not clear whether these companies have a systematic process in place when they are considering payment issues. It could thus be implied that these companies seem to do everything ad hoc and follow their instincts and/or have no methodology.

The research project is currently conducting case studies on building projects which are using innovative forms of payment systems and have been through a partnering process and from live projects from the retail, commercial and social housing sub-markets. Ideally, all the key members of the supply chain should participate in the conference type discussions. The next phase of the project will result in the development of the computer-based simulator that will be used to analyse and assess alternative payment systems, so as to act as an aid to design or "fine-tune" payment systems to individual projects characteristics and needs, and also be used by projects' stakeholders to forecast and plan their cash flow once a payment system is defined.

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Benchmarking Construction Firm Performance

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Abstract

Existing construction benchmarking models have four basic limitations if they are to be used for firm analysis on a company-wide basis. The first limitation is that the existing benchmarking models are project-specific. Second, as a consequence of being project-specific, they do not allow the measuring of the impact of certain technological and managerial attributes on overall firm performance. Third, current benchmarking models do not take note of trade-offs between the different metrics of performance. Fourth, the relationship between how much was expended on the metrics and the performance of those metrics (a return on investment of sorts) is absent.

This paper critiques existing construction benchmarking models and proposes a new construction benchmarking model that provides a performance metric for measuring firm performance on a company-wide basis and supports trade-off analysis among several performance metrics. Additionally, the proposed model relates the effort expended on the metrics of performance to the level of performance of those metrics and aids in the identification of management practices that lead to superior performance.

Key Words: IT utilization, construction, industry, contractor, performance, research, managerial attributes

1. Introduction

In recent years, the construction industry has recognized benchmarking as a possible catalyst for aiding the performance of the industry and improving its competitive edge in the global market. Benchmarking aims at comparing the performance of firms relative to each other, allowing these firms to recognize their weaknesses and strengths compared to the industry. It aids in the identification of industry leaders who exhibit superior performance as a result of using best industry practices. Since the time when the construction industry recognized benchmarking in this way, there have been several benchmarking models proposed. El-Mashaleh [1] critiques these benchmarking models and argues that, if the goal is to measure company-wide performance, they all fall short in four respects.

First, the existing benchmarking models are project-specific. This limited view communicates a single metric performance on a single project and by no means translates to the overall performance of the firm. Second, as a consequence of being project-specific, the existing benchmarking models do not allow the measurement of the impact of certain technological and managerial attributes on overall firm performance. Third, the current benchmarking models do not support an understanding of the trade-offs among the different metrics of performance. Fourth, the relationship between how much was expended on the metrics and the performance of those metrics (basically a return on investment) is absent.

In a highly competitive environment, the long-term success of construction firms depends on improving performance by continually acquiring and applying new knowledge. Existing models have limitations in their ability to guide the industry into both benchmarking and identifying practices of superior performance.

This paper proposes a new construction benchmarking model that provides an overall performance measure for the firm and supports trade-off analysis among the several performance metrics. Additionally, the proposed model relates the effort expended on the metrics of performance to the level of performance of those metrics and aids in the identification of management practices that lead to superior performance. The proposed benchmarking model is deployed using data that was collected from 74 construction firms.

2. Previous Benchmarking Models

Camp [2] defines benchmarking as "the continuous process of measuring products, services, and practices against the toughest competitors or those companies recognized as industry leaders." CII adopts the following definition of benchmarking: "a systematic process of measuring one's performance against results from recognized leaders for the purpose of determining best practices that lead to superior performance when adapted and implemented." [3] The following discussion presents three construction benchmarking models:

- Fisher et al. [4]
- Hudson [3] and CII [5]
- CBPP [6]

2.1 Fisher et al. Benchmarking Model

The Fisher et al. [4] benchmarking model was probably the first notable benchmarking effort in the history of the construction industry. Houston Business Roundtable (HBR) assembled a group of owners and contractors to solicit ideas and compile initial benchmark data for use by the construction industry. Data were collected from 17 companies for 567 projects regarding actual versus authorized cost, actual versus target schedule, actual versus estimated construction labor, and change orders versus original authorized cost (scope changes). Fisher et al. [4] summarized the results in the literature and these results should be studied by all who wish to learn about how well companies and owners do at predicting cost and schedule of projects and related topics.

2.2 Hudson and CII Benchmarking Model

Hudson [3] performed his benchmarking study under the guidance of the Benchmarking and Metrics Committee (BM&M) of CII. The database of this report consists of 901 projects from 37 owner and 30 contractor companies. The report supplies these norms depending on type of construction, project size, project nature, and project location.

2.3 Construction Best Practice Program Benchmarking Model

The Construction Best Practice Program (CBPP) benchmarking model is also known as the Key Performance Indicators (KPIs) model. The CBPP [6] indicates that the purpose of the KPIs, developed and implemented in the UK construction industry, is to benchmark a project or a company against the range of performance currently being achieved across the industry. It provides a framework to check how a construction business compares with the rest of the industry and helps firms to focus on their main priority areas of improvement.

The CBPP [6] argues that clients of the construction industry want their projects delivered on time, under budget, safely, efficiently, free from defects, and by profitable companies. The ten KPIs reflect the aforementioned criteria, as seven of the indicators relate to project performance, while the rest relate to company performance.

3. Critique of Existing Models

The reasons that existing models fall short of measuring company-wide performance were analyzed. The reasons can be categorized into the four areas discussed in the Introduction.

3.1 Measuring Project-level Industry Norms of Some Performance Metrics

The results of measuring project-level industry norms on a few, even well-chosen, metrics by no means translates to the overall performance of the firm. There are no answers to the question: where does a certain firm stand compared to other firms when considering overall performance (i.e., all metrics simultaneously)? An overall performance report card for the firm is sought. Overall performance takes on a particular importance to guard against improvement in one metric while losing on other metrics. Towill [7] stresses that “it is important to emphasize that improvement in one business performance metric (say cost) must not be sought at the expense of another (say quality or safety)”

3.2 No Measurement of the Impact of Technological and Managerial Attributes on Firm Performance

As a consequence of being project-specific, the existing benchmarking models do not allow measuring the impact of certain technological and managerial attributes on overall firm performance. The current models account for such measurement but on a single metric performance (i.e., impact of team building on schedule performance on a certain project). This limitation makes it difficult to identify practices that lead to superior company-wide performance. For example, advances in technology have been widely regarded as major sources of improvement in the competitive position of firms and industries, but, using existing models, overall firm performance cannot be tied to the level of technology adoption or utilization.

3.3 Tradeoffs Among Different Metrics of Performance

The current benchmarking models do not support an understanding of the trade-offs among the different metrics of performance. For example, if the firm’s cost performance has improved, but schedule performance has declined, how can one determine whether this trade-off is favorable or not favorable? That is, whether the overall performance of the firm is better or worse? McKim et al. [8] mention this trade-off among the different metrics of performance when they state that “as various techniques are available to control the cost, schedule, and quality individually, these three indicators of performance are highly interrelated and effect one another…these indicators are highly interrelated and require some balance and trade-off among them to achieve efficient overall control over project performance.”

3.4 Cost / Performance Relationships

The relationship between how much was expended on the metrics and the performance of those metrics is absent in existing models. Two firms that arrive at the same performance are considered to be similarly efficient. This is clearly not the case if one firm is expending more resources (i.e., money, personnel, etc.) than the other firm. It makes more sense to consider the firm that commits fewer resources to arrive at a certain performance as a better performer than the firm that is spending more resources to arrive at the same performance.

4. Benchmarking Model Development

4.1 Development of Metrics of Performance

Camp [2] and Spendolini [9] argue that identifying what is to be benchmarked, or the benchmarking metrics, is often one of the most difficult steps in the benchmarking process. Hudson [3] indicates that the BM&M committee adopts the following definition for a metric: "a quantifiable, simple, and understandable measure which can be used to optimize performance." Hudson [3] also indicates that the BM&M committee adheres to the following principles for metrics used in the CII benchmarking system:

- A metric must provide a value to its stakeholders.
- A metric must focus on continuous improvement and establish an objective target.
- A metric can be influenced by adoption of better practices.

Additionally, Hudson [3] recommends utilizing "The Metrics Handbook" for devising metrics. "The Metrics Handbook" is published by the United States Air Force [10]; it characterizes a good metric as one that conforms to the following attributes:

- It is meaningful in terms of customer requirements.
- It tells how well organizational goals and objectives are being met through processes and tasks.
- It is simple, understandable, logical, and repeatable.
- It shows a trend, i.e. measures over time.
- It is unambiguously defined.
- Its data are economical to collect.
- It is timely.

Camp [2] states that benchmarking metrics are determined from the basic mission of the organization or business unit. How important are these benchmarking outputs or metrics in satisfying end users or customer needs? Ultimately a process exists for this purpose only and whether it should be benchmarked depends on the answer to this question. Benchmarking is the mechanism to ensure that customer needs are satisfied by industry practices. Spendolini [9] supports Camp's statement by linking what is to be benchmarked to the Critical Success Factors (CSF) of a business, which are the factors that have the greatest impact on the performance of the organization. Watson [11] defines CSF as "the limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where 'things must go right' for the business to flourish. If results are not adequate, the organization's efforts for the period will be less than desired. CSF are measured in basic business terms and are selected as measures of business effectiveness (quality), efficiency (cycle time), or economy (cost)."

To guide the selection of the benchmarking metrics, Camp [2] and Spendolini [9] recommend posing Xerox's ten questions:

- What is the most critical factor to business success (e.g., customer satisfaction, expense to revenue ratio, return on asset performance)?
- What factors are causing the most trouble (e.g., not performing to expectations)?
- What products or services are provided to customers?
- What factors account for customer satisfaction?
- What specific problems (operational) have been identified in the organization?
- Where are the competitive pressures being felt in the organization?
- What are the major costs (or cost "drivers") in the organization?
- Which functions represent the highest percentage of cost?
- Which functions have the greatest room for improvement?
- Which functions have the greatest effect (or potential) for differentiating the organization from competitors in the market place?

For the most part, the literature bases performance upon schedule adherence, cost performance, customer satisfaction, safety performance, and profit. Therefore, this research considers company-wide performance based on these five metrics. These metrics along with the associated method of measurement and calculation are shown in Table 1, which also shows that schedule performance is measured in terms of how often projects are delivered on/ahead of schedule. Similarly, cost performance is measured in terms of how often projects are delivered on/under budget. For both metrics, schedule and cost, the measurement is limited to projects closed in the last two fiscal years.

Customer satisfaction is measured in terms of the percentage of repeat business customers. Net profit after tax as a percentage of total sales for the last fiscal year is used to measure profitability of the firm. Safety performance is based on two indicators: Experience Modification Rating (EMR) and OSHA recordable incidence rate.

Table 1: Metrics of Performance Along With Their Measurement Method

Metric	Measurement/Calculation
Schedule performance	Percentage of the time projects are delivered on/ahead of schedule in the last 2 fiscal years (i.e., how often are projects delivered on/ahead of schedule?) Calculation (for projects closed in the last 2 fiscal years): Percentage = [(Number of projects delivered on/ahead of schedule) / (Total number of projects)] * 100%
Cost performance	Percentage of the time projects are delivered on/under budget in the last 2 fiscal years (i.e., how often are projects delivered on/under budget?) Calculation (for projects closed in the last 2 fiscal years): Percentage = [(Number of projects delivered on/under budget) / (Total number of projects)] * 100%
Safety performance	OSHA recordable incidence rate Calculation: Obtain last reported OSHA recordable incidence rate
	Experience Modification Rating (EMR) Calculation: Obtain last reported EMR
Customer satisfaction	Percentage of repeat business customers Calculation: In general, percentage of customers that come back for a repeat business with the firm
Profit	Net profit after tax as a percentage of total sales for the last fiscal year Calculation (for the last fiscal year): [Net profit after tax / Total sales] * 100%

4.1.1 Data Envelopment Analysis

DEA is concerned with evaluation of performance and it is especially concerned with evaluating the activities of organizations such as business firms, hospitals, government agencies, etc. In DEA, the organization under study is called a DMU (Decision Making Unit). A DMU is regarded as the entity responsible for converting inputs (i.e., resources, personnel, money, etc.) into outputs (i.e., sales, profits, customer satisfaction, metrics of performance, etc.). It is their performance that is to be evaluated. DEA utilizes mathematical linear programming to determine which of the DMUs under study form an envelopment surface. This envelopment surface is referred to as the efficient frontier. DEA provides a comprehensive analysis of relative efficiency for multiple input-multiple output situations by evaluating each DMU and measuring its performance relative to this envelopment surface. Units that lie on (determine) the surface are deemed efficient in DEA terminology. Units that do not lie on the surface are termed inefficient and the analysis provides a measure of their relative efficiency.

The following example illustrates the basic idea behind DEA. Figure 1 plots the firms Input x1/Output y and Input x2/Output y as axes. From the efficiency point of view, it is natural to judge firms that use fewer inputs to get one unit of output as more efficient. Therefore, the line connecting C, D, and E is the "efficient frontier." This frontier should touch at least one point and all points are therefore on or above (in this case) this line. All the data points can be "enveloped" within the region enclosed by the frontier line, the horizontal line passing through C, and the vertical line through E, suggesting the name Data Envelopment Analysis.

The relative efficiency of firms not on the frontier can be measured by referring to the frontier point in the example. Say Firm "A" is inefficient. To measure its inefficiency, let OA, the line from zero to A, cross the frontier line at P. Then, the efficiency of A is to be evaluated by: OP/OA = 0.8571.

The analysis can be extended to identify improvements by referring inefficient behaviors to the efficient frontier. The projected values for inefficient firms to become efficient can be calculated. From Figure 1, Firm A for example, can be effectively improved by movement to P with Input x1 = 3.4 and Input x2 = 2.6. The coordinates of P (3.4 , 2.6) are the projected values for A to become efficient. In the same sense, Firm B can be improved by movement to Q with Input x1 = 4.4 and Input x2 = 1.9.

The metrics of performance shown in Table 1 are the outputs to be used in conjunction with the proposed benchmarking model. Two inputs are accounted for in this part of the model: expenses on safety as a percentage of total sales and expenses on project management as a percentage of total sales. By considering these two inputs, the benchmarking model is relating the effort expended on the metrics of performance to the performance in the areas of those metrics. Firms that spend more on project management are expected to have better schedule performance, cost performance, customer satisfaction, and profit. Similarly, firms that spend more on safety are expected to have better safety performance.

Expenditures on safety are annual cost of safety programs and salaries of safety personnel. Expenses on project management are project management personnel salaries, annual costs of project management training, and annual costs of project management software acquisitions and updates. The reciprocal of EMR and OSHA incidence rate are used as the benchmarking model variables in order to convert these unfavorable measures to favorable ones, since the lower the values of EMR and OSHA incidence rate, the better the safety performance.

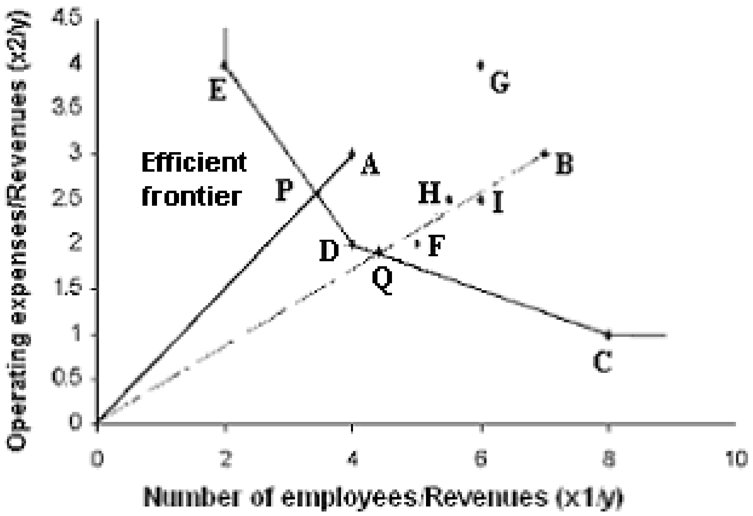

Figure1. Firm Efficiency as shown by DEA

5. Data Collection

The data for this research were collected through a survey questionnaire that collects general information about the person completing the survey, general information about the firm, and the performance of the firm on a company-wide basis. Firms are asked to supply their Schedule Performance, Cost Performance, Safety Performance (OHSA incidence rate and EMR), Customer Satisfaction, Profit, expenses on safety, and expenses on project management. The survey questionnaire was posted on the University of Florida web site and 545 practitioners were contacted by e-mail to fill out the survey. The research team received 88 responses, which accounts for a 16.15% response rate. The 88 respondents represent 74 firms.

6. Results and Analysis

This section benchmarks firms based on their performance against five metrics of performance: schedule adherence, cost performance, customer satisfaction, 1/EMR, and profit. The benchmarking analysis identifies efficient and inefficient firms and supplies inefficient firms with projected values for the metrics of performance. These projected values serve as a road map for inefficient firms to improve their performance and become efficient.

6.1 General Information

Fifty-two percent of respondents were upper management, 28 percent were middle management, and 13 percent were lower management. Forty-three percent of the firms that the respondents worked for were general contractors (GC), 29% were companies that could function as a GC or construction managers (CM), 10% were CM firms, and the rest were some combination of design-build, GC, CM, subcontractors, or specialty contractors. Thirty-one percent of the firms work solely in the commercial construction area, 23% do commercial or industrial construction, 12% do commercial, residential, or industrial construction, and the rest were made up of heavy/highway contractors or some combination of some or all previously-mentioned areas of construction. Figure 2 shows the sizes of the firms, by revenue. Table 2 provides descriptive statistics for the metrics of performance along with the number of firms. OHSA recordable incidence rate is not reported because only a few firms supplied it.

6.2 Benchmarking Firms' Performance

Several DEA models were developed to benchmark firms' performance. Table 3 shows two of these. Model 1 is named FULL since it includes all metrics of performance and has both inputs. Model 2 is named SCCPE because it includes the following metrics: Schedule Performance, Cost Performance, Customer Satisfaction, Profit, and EMR. Model 2 uses unity (1) as input, just as several examples found in DEA literature [12] , Ozcan and McCue [13]. The reason behind using "1" as input lies in the fact that few firms supplied sufficient details in answering this part (expenses on safety and expenses on project management) of the survey questionnaire.

6.2.1 Model 1: FULL

For the FULL model, scores average 0.88 with a standard deviation of 0.23. The highest score is 1.0 and the lowest score is 0.22. Among the 21 DMUs, 16 are efficient (score = 1.0) and 5 are inefficient (score < 1.0).

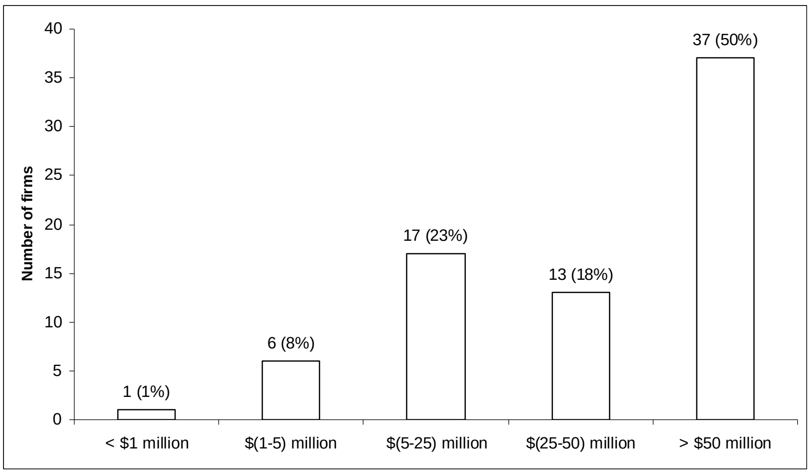

Figure 2. Firms' Revenue

Table 5 supplies the projected values for seven important metrics. The projected values are of particular importance to inefficient DMUs. By arriving at the projected values, inefficient DMUs have the opportunity to become 100% efficient. For example, in order to be considered efficient, Firm AN has to reduce safety expenses and project management expenses by 54% and

Table 2: Metrics of Performance Descriptive Statistics

Metric	Number of firms	Mean	Sd	Min.	Max.	25th Quartile	75th Quartile
Schedule performance (%)	69	80.3	23.12	10	100	75	95
Cost performance (%)	69	81.75	15.22	10	100	75	90
Customer satisfaction (%)	67	60.34	25.25	10	100	40	80
EMR	35	0.702	0.1356	0.45	0.95	0.61	0.8
Profit (%)	23	3.066	2.645	0.14	12	1.5	3.875
Safety expenses (%)	43	0.98	1.344	0.1	5	0.25	1
Project management expenses (%)	40	4.311	3.26	1	12	2	6

48.7% respectively. At the same time, AN has to improve its schedule performance, cost performance, 1/EMR, customer satisfaction, and profit by 5.26%, 7.69%, 4.11%, 26.92%, and 120.73% respectively. By meeting the above criteria (reducing inputs and improving outputs), AN can raise its score to 1.0 and can then be considered 100% efficient.

Table 3: DEA Models to Benchmark Performance

Model #	Model name	Number of firms	Inputs	Outputs
1	FULL	21	– Project management expenses – Safety expenses	– Schedule performance – Cost performance – Customer satisfaction – Profit – 1/EMR
2	SCCPE	28	1	– Schedule performance – Cost performance – Customer satisfaction – Profit – 1/EMR

6.2.2 Model 2: SCCPE

This model includes 28 firms. The outputs are: schedule performance, cost performance, 1/EMR, customer satisfaction, and profit. Table 7 provides descriptive statistics for the results of the SCCPE model. The scores average 0.943 with a standard deviation of 0.0888. Again, the highest score is 1.0 and the lowest score is 0.602. Ten DMUs are efficient, while 18 are inefficient. The information from the SCCPE model can be used in exactly the same way as the information from the FULL model.

Table 5: FULL Model Results

No.	DMU Input/Output	Score Data	Projection	Difference	%
5	AN	0.51			
	Safety expenses (%)	0.25	0.115	-0.135	-54.00%
	PM expenses (%)	1.95	1	-0.95	-48.72%
	Schedule performance (%)	47.5	50	2.5	5.26%
	Cost performance (%)	65	70	5	7.69%
	1/EMR	1.31	1.37	0.05	4.11%
	Customer satisfaction (%)	65	82.5	17.5	26.92%
	Profit (%)	2.05	4.525	2.475	120.73%

7 CONCLUSIONS

This is the first construction benchmarking model introduced to the industry that accurately rates the efficiency of a construction firm on a company-wide basis and identifies the areas that the firm must improve upon in order to be the on par with the most efficient firms in the industry. It accomplishes this by measuring a firm against the five metrics identified by a consensus of the literature as the five most important measures of company efficiency.

The model also produces and reports the magnitude of the deficit that a company must overcome in each of the five areas measured in order to become as efficient as the most-efficient firm(s) in the industry.

The data from a diverse set of 74 firms, randomly chosen were analyzed and then two different versions of the model were validated. Each model performed satisfactorily, identifying the efficient firms and instructing the inefficient firms about where to concentrate their efforts and telling them how much improvement is needed in each area measured.

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A comparison of social housing in the Netherlands and England on characteristics and quality

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Abstract

The Netherlands and England both have a large social housing stock. In this article the two countries are compared on sector and stock characteristics, the quality and backlog of the stock, and investment and maintenance expenditure.

Both countries show a declining tendency in the social housing stock. Social management bodies are strongly urged to develop businesslike approaches to housing management. There are differences in the way the management of the property is organized (private or public), independency of operations, regulatory systems and supervision requirements. The housing stock in both countries have many characteristics in common. A significant difference is the age of the stock.

The quality of the stock is measured in both countries periodically by central government (KWR in the Netherlands and HCS in England). Significant improvements in the quality of the stock has been achieved. In both countries the social rented housing stock had the lowest quality backlog of all ownership categories. Although there are differences between local authorities and housing associations, the overall quality of social housing in England is somewhat higher than in the Netherlands. Total investment and maintenance expenditure are on the same level. Within this total expenditure there are differences between the two countries and between social housing management bodies in England. The expenditures are in line with the backlog.

It’s interesting that the quality survey in England is based on a quality standard (Decent Home Standard). Decent Home Standard defines the future agenda. All social houses must satisfy the decency criteria in 2010.

Keywords: social housing, characteristics, quality, backlog, maintenance

1. Introduction

Thirtyfive percent (Netherlands) and eighteen percent (England) of the housing stock is managed by social landlords. The proportions in other West European countries are lower. From this perspective it's interesting to compare the Netherlands with England. The main objective is to study the differences and similarities in social housing in the two countries.

We first look at the circumstances and conditions (i.e. the housing stock characteristics, national legislation and housing stock policy) before comparing the quality and backlog of the social housing stock. Both countries periodically survey the quality of the housing stock. Next we will inventorize the investment and maintenance expenditure per dwelling and the underlying maintenance types. For the sake of comparison it is interesting to look at the relationship between the quality and backlog of the stock and the investment and maintenance expenditure.

OTB Research Institute organized an enquiry on strategic stock management and maintenance management among all housing associations in the Netherlands in 2004 [16]. The results have been used in this article. The information on the social housing stock in England was gathered by means of an extensive literature review and contacts with the University of Greenwich in England. The following research questions will be dealt with in this article:

- what are the characteristics of the social housing sector in the Netherlands and England?
- what are the characteristics of the social and other housing stock in both countries?
- what is the quality and backlog of the social housing stock?
- what are the levels of investment and expenditure on maintenance in social housing in both countries?
- is there a relationship between the expenditure or investment and the quality and backlog of the social housing stock in the two countries?

We end the article by presenting our conclusions, along with an outline of developments and relevant recommendations.

2. Social housing in the Netherlands and England

The social rented housing stock in the Netherlands is 2.4 million homes and is almost entirely in the hands of housing associations. The social housing stock accounts for 35% of the total housing stock in the Netherlands. There is also a small private rented sector (12%). A little over half the stock is owner-occupied (table 1). The proportion of social housing is reasonably stable, but is decreasing slightly, partly as a result of housing association sales programmes. In addition, most new building is for owner-occupied housing.

Until recently, the municipalities also managed part of the social housing (municipal housing departments). The housing associations were privatized in the mid 1990s, in which the municipalities had a supervisory role. To avoid problems of being seen to wear 'two hats' (i.e. management and supervision), it was then decided to phase out the municipalities' management role. The property of municipal housing departments was gradually transferred to housing associations. Currently, 540 housing associations manage an average of 4,335 homes [1, 16]. Approximately 10% of the management organizations manage over 10,000 homes.

Table 1: Division of housing stock by tenure in the Netherlands and England

Percentage of total housing stock	Social rented	Private rented	Owner-occupied
Netherlands	35%	12%	53%
England	18%	10%	72%

Source, VROM, 2003 and National Statistics, 2004

England has 3.8 million social rented homes, which amounts to 18% of the total housing stock (21.5 million homes). As in the Netherlands, the private rented sector is small (10%), and more than 70% of the stock is owner-occupied.

Sixty six percent of the social housing in 2003 was in local authority hands (i.e. public housing companies), and the other 32% in the hands of housing associations [9]. Although most of the almost 2,000 housing associations are voluntary not-for-profit organizations, they operate under close government regulation and are registered as social landlords (RSLs), and the majority are affiliated with the Housing Corporation (HC). This umbrella organization was set up by, and is supported financially by, the government. The HC is responsible for public and private investments in the corporation sector and oversee the RSLs.

Table 2: Characteristics of social landlords in the Netherlands and England

Characteristics	Netherlands	England	
	Housing associations	Local authorities	RSLs
Total housing stock	6.7 million	21,5 million	
Social housing stock	2.4 million (35%)	3.8 million (18%)	
Number of homes	2.4 million	2.6 million	1.2 million[1]
Number of landlords	540	241	1,925
Dwellings per landlord (average)	4,335	10,788	623

Source, VROM, 2003 and National Statistics, 2004

Public housing company ownership in England is being scaled down sharply. In 1979, they managed 5.1 million of the 5.5 million social homes [14]. Between 1980 and 1990, the total social housing numbers fell to 4.4 million, most importly because of the sale of 200,000 homes to tenants. Social housing numbers dropped further in 2003 to 3.8 million. As well as the sales, a feature of recent years has been the transfer of 350,000 homes from local authorities to RSLs [11]. The public housing companies managed 2.6 million homes in 2003 and the RSLs 1.2 million [9].

Public housing companies are large management organizations that handle on average more than 10,000 homes. RSLs are considerably smaller, managing on average as few as 1,000 homes. The vast majority of RSLs are extremely small, with the largest 10 managing on average 23,700

[1] Excluding 645,000 LSVT dwellings

homes. The RSL sector is very diverse. There is “a wide range of quite different organizations, varying from ancient almshouses trusts and Victorian charitable foundations to self-build co-ops and former local authority housing departments” [14]. The transfer of ownership from housing departments to RSLs has caused a rise in the average number of homes in management.

Table 3: Characteristics of social housing stock in the Netherlands and England

Characteristics	Netherlands	England	
	Housing associations	Local authorities	RSLs
Typology houses versus flats	70-30	67-33	60-40
High-rise flat		8%	2%
Age profile of the stock: <1945 versus >1945	9-91 (49% 1945-1975)	32-68 (42% 1945-1965)	30% after 1985
Number of rooms	2.3	2.5	2.4
Useable floor area houses/flats	90-68 m2	93-59 m2 (total stock)	

Source, VROM, 2003 and National Statistics, 2004

3. National legislation and strategic housing stock policy

Dutch housing associations are not-for-profit organizations, which are obliged to operate in the interest of housing, in particular by providing decent, affordable housing to lower-income households. This is reflected in the Housing Act and the Social Rented Sector Management Decree (BBSH), which states the rights and obligations of Dutch housing associations [10, 13]. In the 1990s, the national government granted social landlords considerably greater freedom of policy, but also diminished the financial support to social landlords. Furthermore, demand for social housing decreased, partly because of a booming economy and changes in housing preferences towards home ownership. As a consequence, housing associations in the Netherlands began to adopt businesslike approaches in their housing management. They had to operate in a more market-driven and client-driven way. For technical management, only the lower limits have been set. All dwellings have, at any rate, to satisfy the minimum requirements of the Dutch Building Decree.

In England, local authorities and housing associations operate within different statutory, regulatory and funding frameworks. They started independently and developed along different legislative paths. Nevertheless, both parts of the social rented sector have some key similarities. The stock has been provided through public subsidy and is subject to regulation (e.g the Housing Act, the Housing Association Act and the Landlord and Tenant Act). Rents are set below market levels. Like the Netherlands, both local authorities and housing associations are under pressure to develop businesslike approaches towards housing management [14]. From 2001/02, local authorities in England have started to operate under a new financial framework. The associated introduction of business plans is part of the process of encouraging authorities to make better use of their housing assets [2]. These business plans draw on an investment plan informed by condition stock surveys. The recent government agenda for social housing policy was set by the Housing Green Paper [3]. This is a wide agenda that covers many subjects. The agenda for the future emphasizes a more strategic role for local authorities and the need to prepare housing strategy statements that are tuned to regional and national agendas and objectives.

Local authorities and housing associations are responsible for their own investments and the maintenance of their stock. In contrast to housing associations, local authority investment continues to be eligible for central government support (grants for disabled facilities and, from April 2001 onwards, the Major Repair Allowance). Local authority Housing Investment Programme (HIP) allocations are based on government assessment of requirements for housing investment, informed by local housing strategies and, from 2004, by the priorities set out by Regional Housing Boards.

Housing associations are subject to the Housing Corporation’s Regulatory Code, which requires RSLs to operate viable businesses with adequate resources to meet current and future business and financial commitments. All business plans are assessed by a lead regulator of the Housing Corporation to check compliance with regulatory requirements [4]. The inspections (oriented to RSLs with more than 250 homes) cover six housing association duties, including maintenance and investment. RSLs must fund all their maintenance and investment plans from their own resources. RSLs must operate a clear asset management strategy and develop clear plans for bringing the housing stock into compliance with the Decent Home Standard by 2010 (see section 5).

Strategic housing stock policy is generally accepted within large social housing associations in the Netherlands. In a housing stock policy document, a housing association constructs a picture of the composition of the desirable dwelling portfolio and sets up market and complex strategies [15, 16].

4. Quality and backlog social housing stock Netherlands

The physical quality of the Dutch housing stock and living environment is measured periodically (i.e. every five to six years) in a Qualitative Housing Survey (KWR). The last comprehensive investigation was carried out in 2000 [7]. The KWR focuses on the structural state of the building, the functional quality, energy-saving measures, security facilities and the spatial quality of the living environment.

The Dutch housing stock consists of 70% single-family and 30% multi-family homes (Table 3). The local and regional differences are large, and indeed, the proportion in the major cities is exactly the opposite.

The *structural quality* is expressed in the necessary repair costs to remedy overdue maintenance and defects. The average repair costs for the entire Dutch stock fell between 1990 and 2000 by 40%, from € 4,200 to € 2,500 per home. For the total stock, this equates to a fall from € 24.3 to € 16.4 billion. The quality improvement arises largely from an improvement of the prewar stock, which is the group of homes that the urban renewal of the 1980s and 1990s focused on [7]. The Dutch social rented housing stock is in good structural condition. The average repair costs are € 2,200 per home.

Exterior frames, roofs, sheds or garages, external walls and ceilings are the most important repair items, accounting for two-thirds of the repair costs. The other structural and installation elements are responsible for the remaining repair costs.

The repair costs are then corrected in the KWR for the size of the home, which is then expressed as relative repair costs. The relative repair costs are a percentage of the rebuilding costs of the home. Four classes are distinguished (Excellent - less than 1%, Good - 1-10%, Moderate - 10-20% and Poor - >20%)

Approximately 8% of the total stock is in the moderate (6%) to poor (2%) categories. In 1990 this percentage was 27%. Considerable improvements are therefore also apparent in the relative repair costs. The social rented housing stock has the best statistics, with only 4% of stock in the moderate (3.5%) to poor (0.5%) classes.

The KWR also investigated the residents' satisfaction with the state of repair of the home. Not surprisingly, the residents of poor and moderate homes were considerably less satisfied with the structural state than residents of good and excellent homes.

Functional quality is an important indicator of usable area. The average usable area of the Dutch housing stock is 104 m2 (single-family home: 118 m2 and multi-family home: 72 m2). Social housing is considerably smaller than the average, with a typical single-family home being about 90 m2 and a multi-family home 68 m2. The level of facilities in the home increased sharply in the 1990-2000 period, and the same applies to internal and external accessibility. For internal accessibility, the living room, kitchen, sanitary facilities and at least one bedroom are situated on one floor. 37% of the total housing stock satisfies this criterion. For the social housing stock, the figure is almost 50%. For external accessibility, the home must be accessible from outside without needing to climb stairs. Three quarters of the Dutch housing stock is completely accessible, which is mainly because of an increase in the number of multi-family homes with a lift. Corporations have installed a relatively large number of lifts in their early postwar stock.

Table 4: Quality of the social housing stock in the Netherlands and England

<table>
<tr><th></th><th>Netherlands</th><th colspan="3">England</th></tr>
<tr><th></th><th>Housing associations</th><th>Local authorities</th><th>RSLs</th><th>Total</th></tr>
<tr><td>Backlog in technical quality (per dwelling)</td><td>€ 2,200
(€ 2.500 total stock)</td><td rowspan="2">€ 2,416[2]
(€ 5,619 per non decent dwelling)</td><td rowspan="2">€ 1,497[3]
(€ 5,344 per non decent dwelling)</td><td rowspan="2">€ 2,111
(€ 3,519 total stock[4])</td></tr>
<tr><td>Backlog in housing quality (functional, energy etc)</td><td>Not known</td></tr>
<tr><td>Central heating</td><td>84%</td><td>84%</td><td>80%</td><td>82%</td></tr>
<tr><td>Double glazing</td><td>69%</td><td>60%</td><td>74%</td><td>65%</td></tr>
<tr><td>Wall insulation</td><td>55%</td><td>Unknown</td><td>Unknown</td><td>Unknown</td></tr>
<tr><td>Floor insulation</td><td>30%</td><td>Unknown</td><td>Unknown</td><td>Unknown</td></tr>
<tr><td>Secure windows and doors</td><td>Unknown</td><td>42%</td><td>55%</td><td>46%</td></tr>
</table>

Source, bewerking KWR, 2003 and ODPM, 2003

The *energy quality* of the housing stock is an important topic. The Netherlands is striving for a 10% CO_2 reduction in the existing stock in 2010 relative to 1990. One of the most important energy-saving measures is insulating the shell of the home. KWR 2000 shows that the necessary progress is being made: The proportion of homes with double glazing rose from 57% to 69%, the proportion of homes with wall insulation from 42% to 50%, the proportion of homes with roof insulation from 51% to 63% and the proportion of homes with floor insulation from 24% to 34%. If we focus on the social housing stock, then it appears that the sector has performed several percentage pints better than the average for wall insulation, approximately equal to the average for double glazing, and a few percentage points below average for floor insulation and roof insulation.

Eighty four percent of space heating in the social rented sector is provided by an individual central heating installation. The proportion of local heating has declined steadily. Tap water is heated in 52% of the homes by a combination boiler, but kitchen and bathroom water heaters and storage water heaters are still common. The social housing stock is in line with these average levels. The proportion of solar water heaters in the total housing stock is only 1%.

5. Quality and backlog social housing stock in England

A Public Service Agreement (PSA) was concluded in 2000 between the government and the social rented sector (local authorities and housing associations). The agreement is that all social rented housing will achieve a quality level in 2010 in line with the Decent Home Standard. The Decent Home Standard distinguishes the following four assessment criteria.

[2] This is the average of all 2,79 million local authority dwellings (2001). 43% of the stock is non-decent. € 5,619 per dwelling (see table 5). Exchange rate £ 1 to € 1.47
[3] This is the average of all 1,388 million RSL dwellings (2001). 28% of the stock is non-decent. € 5,344 per dwelling.
[4] This is the average of all 21,141 million dwellings in England (2001). 33% of the stock is non-decent. € 10,556 per dwelling.

- The minimum fitness standard. The fitness standard states that there must be no serious defects, that the home is structurally safe and healthy, that facilities are present for heating, lighting and ventilation, and that the home has tap water, sewers, a WC and a bath or shower and cooking facilities.
- The repair criterion. Twelve essential and three ordinary building components are distinguished. Building components refer to the constructional, shell and internal building elements. The assessment is made on the basis of the age and the state of a building element. Guidelines have been drawn up for the age and state of each building element. A home is deemed to be non-decent if one or more essential, or two or more other building components are old and in need of replacement or drastic attention with respect to their state of repair.
- The modern facilities criterion. A home is assessed on six facilities (e.g. kitchen, bathroom and sound insulation), primarily on age, area, etc.. If the home does not satisfy three or more of these requirements, it is deemed non-decent.
- The thermal comfort criterion. A home must have both efficient heating and effective insulation. Efficient heating is defined as a programmable central heating or heater. The effective insulation requirement (thickness) depends on the type of heating. In the case of gas and oil-fired heating, there must be an insulation package of at least 50 mm in the external walls and roof. In the case of electrical, LPG and solid fuel heating (e.g. wood), the package must be at least 200 mm thick.

Table 5: Social housing stock failing the Decent Home Standard in England

	Total stock	Social housing		
		Local authorities	RSLs	Total
Total percentage failing DHS	33%	43%	28%	38%
Failing Modernization	2%	6%	2%	5%
Failing fitness	4%	5%	3%	4%
Failing disrepair	9%	9%	5%	8%
Failing thermal comfort	26%	34%	22%	30%

Source, ODPM, 2003

The quality of the UK housing stock is measured in the Housing Condition Surveys. Like the KWR, the measurements are made periodically. The last comprehensive measurement was in 2001, and before that in 1996 [11, 13].

For the total stock, one third of the homes were non-decent in 2001, whereas the figure in 1996 was still 46%. Therefore, as in the Netherlands, there has been a considerable jump in quality. This improvement can partly be explained by the construction of over 800,000 new reasonably high quality homes in the period concerned (the stock expanded between 1996 and 2001 by approximately 4%). However, the 13% jump in quality is several times as high as this expansion.

As table 4 shows, backlog is defined somewhat more broadly in the House Condition Survey than in the Netherlands. In the Netherlands, reliable backlog data is available only on the basis of technical quality, while in the UK the Home Standard also incorporates housing quality in a broader sense (e.g. functional quality and energy) alongside technical quality. The total backlog for the UK housing stock is € 74 billion, which is equivalent to an average of € 3,419 per home.

Social housing stands out in a positive sense, where the backlog of € 9 billion, or € 2,111 per home, is considerably lower than the average for the total housing stock. In 2001, 38% of social housing was non-decent. The quality improvement in the 1996-2001 period is in line with the national trend. In 1996, more than half (i.e. 52%) of the public sector stock was non-decent.

If we focus on the social landlords, local authority property would appear to be in somewhat poorer condition than that of the housing associations, with 43% being labeled non-decent. Otherwise, the backlog per home for this category is still more than € 1,100 lower than the average UK home (average € 2,416 per home). Local authorities can tackle the non-decent homes themselves, but alternatives are also offered to them:

- setting up an Arms Length Management Organization (ALMO), in which the municipality sets up a sort of private company to manage and repair the homes;
- joining the Private Finance Initiative (PFI), i.e. entering into (30 year) contracts through government-supported Public Private Partnerships, where the municipality continues to own the homes, but the private sector takes responsibility for the administration and management;
- transfers of ownership to a housing association (RSL), which then repairs the property (364,000 in the 1996-2001 period).

There were 138 transfers, 36 ALMOs were founded and 16 PFI contracts were concluded in the 1997-2004 period [5].

The property of the housing associations stands out positively in terms of quality, in that ‘only’ 28% is non-decent, and the backlog is only € 1,497 per home. The Housing Corporation itself investigates the affiliated housing associations each year. Data from 2003 shows that the quality increased further in the 2001-2003 period to 23% non-decent [5]. The backlog has therefore continued to decline in recent years.

The most common reason for a dwelling being deemed non-decent is failure to provide a reasonable degree of thermal comfort (about 80%). 34% of all local authority dwellings and 22% of the housing associations' stock fail on thermal comfort (i.e. lack of adequate insulation, poor heating, or both). 82% of the social rented housing has central heating; 65% has double glazing in part or all of the home. The RSL homes are less old and therefore also better insulated.

Another important reason for non-decency is disrepair. Housing associations perform better than the average. The key building components on which dwellings most frequently fail the disrepair criterion are chimneys (28% of all failing on disrepair), windows (26%), wall structure (14%) and roof structure (13%).

A small proportion of the social housing stock fails to satisfy either the minimum fitness standard or the modernization standard. Regarding the modernization standard, the most common contributory factors are the age of the kitchen or the bathroom.

The total of the non-decency criteria exceeds 100%. It goes without saying that homes can be assessed as inadequate on more than one critierion. Older homes are generally of lower quality (i.e. have a higher non-decency rating) than younger homes, and this is particularly true of the fitness and disrepair criteria. Prewar and postwar homes differ little in terms of modernization and thermal comfort.

More than 80% of the tenants are actually satisfied with the housing [9], which means that tenants can still be satisfied with their home in spite of non-decency. In the assessment of the home, matters such as living environment and level of rent naturally also play a role.

6. Investments and maintenance expenditure social housing

The Dutch housing associations spent about € 3 billion in 2002 on maintenance. This is equivalent to € 1,263 per home per year [1]. Besides maintenance, housing associations expended approximately € 2.1 billion per year on investment in existing stock (conversions, renovation). This is equivalent to € 922 per home per year [16].

Table 6 : Investment and maintenance expenditure per year in the existing social housing stock in the Netherlands and England (estimate)

	Netherlands	England		
	Housing associations	Local authorities	RSLs	Total
Total investment in the existing stock (conversions and renovation)	€ 2.1 billion	€ 1.1 billion[5]	€ 2.2 billion	€ 3.3 billion[6]
Investment per dwelling	€ 922	€ 423	€ 1.192	€ 742
Total maintenance and repair expenditure	€ 3.0 billion	€ 3.0 billion[7]	€ 3,0 billion	€ 6.0 billion
Maintenance per home	€ 1,263	€ 1,154	€ 1,636	€ 1,350
Total investment and maintenance	€ 5.1 billion	€ 4.1 billion	€ 5.2 billion	€ 9.3 billion
Total investment and maintenance per home	€ 2,185	€ 1,577	€ 2,818	€ 2,092

Source, Aedes, 2003,Vijverberg, 2005, National Statistics, 2002, Housing Corporation, 2004

The total investment and expenditure on maintenance are almost equal in both countries. In the Netherlands the average level of investments per home is higher and maintenance expenditure lower.

Local authorities in England expended an amount equivalent to € 1.1 billion on conversion and renovation in 2001 [8]. This amount excludes the Private Finance Initiatives (PFI contracts). In addition, local authorities spent € 3 billion on maintenance and repair in 2001. For RSLs the estimate is € 2.2 billion on conversions and renovation and € 3 billion on maintenance in 2003 [6].

[5] Estimate: £ 720 million. Exchange rate £1 to € 1.47

[6] Estimate:£ 18 billion was invested in the 1997-2004 period in existing homes: average £2.25 billion a year. Another £7 billion will be invested in the 2004-2007 period.

[7] £2,046 million

Within social housing in England the housing associations investment and expenditure exceed the local authority expenditure with almost 80%.

Closer analysis of the maintenance expenditure in the Netherlands reveals that routine day-to-day maintenance accounts for about one-third of expenditure (i.e. € 448 per dwelling per year). The remaining € 815 is spent on planned maintenance and major repairs expenditure [1]. For local authority no reliable data was found. For RSLs planned maintenance expenditure is about the same as in the Netherlands. Routine maintenance makes the difference. Expenditure in this maintenance type per home are 82% higher [6].

Table 7: Volume of maintenance business per home according to maintenance type in social housing in the Netherlands and England

	Netherlands		England		
	Housing associations	%	Local authorities	RSLs	%
Routine maintenance	€ 448	35%	Unknown	€ 817	50%
Planned maintenance and major repairs	€ 815	65%	Unknown	€ 819	50%
Total maintenance and repair expenditure	€ 1,263	100%	€ 1,154	€ 1,636	100%

Source, Aedes, 2003, Housing Corporation, 2004

7. Conclusions and recommendations

The Netherlands and England have a large social housing stock. Housing associations have been privatized in the Netherlands, and are responsible for their own financial affairs. Associations are therefore fairly independent in operations. The national and local authorities in the Netherlands retain some influence on the operations through rent policy and admission and supervision requirements.

A substantial proportion of the social housing stock in England is still in public hands. There is more regulation and supervision. There is a division in the social rented housing stock in England, with property falling either under local authorities or housing associations. A similar situation also existed some time ago in the Netherlands. The local authorities in the Netherlands have now transferred the majority of the property to housing associations, with a view to avoiding problems of ‘wearing two hats’ (i.e. management and supervision). There are signs that the same is happening in England. Local authority property is being transferred on a large scale to housing associations. The local authorities still retain the majority of the stock. Another difference with the Netherlands is that the housing associations are small. In order to facilitate professionalization, the property level of the average housing association will probably expand sharply in the coming years. In England too, social management bodies are being strongly urged to develop businesslike approaches to housing management.

Housing associations in both the Netherlands and England are responsible without government support for investments in and maintenance of their stock. It is striking in this regard that housing

associations in England are under the supervision of an umbrella organization (i.e. HC) that was set up and is supported financially by the government.
The social housing stock in the Netherlands and England have many characteristics in common. The distribution between houses and flats, the number of rooms and useable floor area is about the same. A significant difference is the age of the stock. More than 90% of the stock in the Netherlands was built after 1945, whereas the corresponding figure in England is less than 70%.

In both the Netherlands and England, the quality of the housing stock is measured periodically by the government. The Netherlands have the Qualitative Housing Survey (KWR), and in England there is the House Condition Survey (HCS). Most recent investigations have shown significant improvements in the quality of the stock in both countries in recent years, which is attributable partly to building additional new social housing. However, the most important reason appears to be the investment and maintenance programmes. In both countries, the social rented housing stock has the lowest quality backlog of all the ownership categories. The quality backlog of an average public sector home in the Netherlands is € 2,200, and in England the average is € 2,111 per home. However, the measurement of quality backlog in England is not limited to technical quality (as is the case in the Netherlands) but also covers housing quality (e.g. functional and energy aspects) in a broader sense. It therefore has to be concluded that the quality of social housing in England is somewhat higher than in the Netherlands. Otherwise, there is a pronounced difference in quality between local authority and housing association homes in England. The quality backlog of housing local authority property is considerably greater.

The total investment and expenditure on maintenance are almost equal in both countries. In the Netherlands the average level of investments per home is higher and maintenance expenditure lower. Within social housing in England there are big differences between investment and maintenance expenditure of housing associations and local authorities. The figures match with the backlog.

It is interesting that the Decent Home Standard in England is based on the House Condition Survey. The Decent Home Standard distinguishes four criteria on which the quality measurement focuses (i.e. the minimum fitness standard, repair criterion, modernization criterion and thermal comfort). Currently, 38% of the social rented housing stock fails to satisfy one or more criteria. Thermal comfort is the greatest culprit. 80% of the non-decent dwellings are inadequate on this criterion. A Public Service Agreement sets down that all local authority and housing association homes must satisfy the decency criteria in 2010. It would be advisable for the Netherlands to introduce this broad quality measurement approach into the KWR and subsequently to reach performance agreements in national or local covenants between governmental bodies and housing associations.

This research will be continued on links between expenditure, quality and backlog. Is it for instance possible to calculate quality improvement? Therefore we have to get more reliable information on investment and backlog in the social housing stock in England and the Netherlands over a period of time. Another interesting topic for future research is the effectiveness of the combination of condition survey tools and (real-time) quality standards. For that we have to dig deeper into KWR, HCS and quality standards. Maybe it’s interesting to involve other European countries in future research. We are especially interested in North European countries in this perspective (also fairly large social housing stock).

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Information, Technology and Procurement Organization Form

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Abstract

A central theoretical question is how organization makes a difference to economic performance of construction firm. Obviously, technology will have a great bearing on the way a firm performs. The thesis of this paper is that a partner construction firm, by virtue of the fact that it manages the IT function for multiple-discipline construction firms, is privileged to information not available to the focal firm. In this paper I derive the conditions under which privileged information allows the partner construction firm to construct superior incentives for its employees, resulting in superior IT procurement. Further, I detail the circumstances under which outsourcing will not provide additional benefit, and what sorts of partners are likely to provide the greatest benefit. The two main findings are that for low levels of uncertainty, both in-house and relational procurement are equally acceptable. However, as uncertainty increases, the value of relational procurement increases. Conclusions are drawn and extensions are proposed, related to economies of scale and transactions costs.

Keywords: Information Technology, Relational Procurement, Organizational Form

1. Introduction

Although there is good reason to expect that the growth of information work and information technology will significantly affect the trade-offs inherent in different structures for organizing procurement, the theoretical basis for these changes remains poorly understood. Procurement officials and researchers in construction business each suffer from the lack of robust theoretical models that provide sharp, testable predictions.

The ability to manage interorganizational relationships is one of the most valuable capabilities of a firm [1, 4, 12]. Construction firms must not only execute tasks at a frenetic pace, they must also execute a greater number and variety of electronically enabled tasks. This obliges their information technology (IT) infrastructure to be both highly reliable and extremely flexible. As construction firms move away from simply procuring the development of software into multifaceted electronic business infrastructure projects, the nature of the relationship becomes more complex. A rational construction firm would only choose to institute a relationship if it believed that the partner were more able to perform the IT task. This superior performance could manifest in the form of lower costs, higher quality, greater knowledge or a myriad of other factors. While these performance results are widely described, the causal mechanism remains a mystery. What is the resource that the partner brings to the table that cannot be duplicated by the focal owner? These arguments point to the simple fact that the causal mechanisms of value creation from relational procurement are not at all well understood. There exists a fundamental need for reconciliation between procurement's shining triumphs and its glaring failures in construction business. Moreover, as an academic practice, we require a sound explanation about how a resource can exist, which is inimitable to certain firms (focal owners) and yet readily imitable by other firms (partners). In short, the literature requires a reasonable theory of why IT partners in construction business are more capable of providing infrastructure services than focal owners, and of the boundary conditions that explain when partners are not more capable than focal owners.

As introductory work, in this paper, I focus on the specific domain of archetypical outsourcing in information technology infrastructure procurement. I build on the insights of the incomplete contract approach to clarify the mechanisms by which information technology can be expected to affect the organization of procurement activity in construction business. I consider the incentive effects of various allocations of "information assets" as well as physical assets. This approach is particularly appropriate given the increasing importance of information in the procurement process. While many implications are still unexplored and untested in construction business, building on this approach appears to be a promising avenue for the careful, methodical analysis of human organizations and the impact of new technologies in procurement.

2. Literature Review

By far, the most common way of understanding the decision between in-house and relational procurement for IT functions has been transaction cost economics (TCE). TCE seeks to explain the locust of transactions as an attempt to economize on costs [9, 18, 19]. They propose the electronic markets hypothesis, which suggests that IT will reduce transaction costs, and thereby increase the use of market, rather than hierarchical organization [16]. TCE has been used extensively by Clemons and colleges [5, 6, 7, 8]. The most widely known application is the move to the middle hypothesis, which posits that IT not only reduces market transaction costs, but also reduces the transaction costs of hierarchical organization. As Williamson notes "…economizing takes place with reference to the sum of production costs and transaction costs, whence tradeoffs in this respect must be recognized." [19, p. 22]. Thus far, there is a significant gap in the information system (IS) literature in trying to explain both the transaction and production costs (an important exception is [13]).

I seek to fill the production cost gap by developing a formal model to explain the production cost advantages of partners in construction business. However, rather than use the classical economics' concept of a firm as a black box, I use TCE's concept that the organization of the firm is important [10, 19]. Thus, I propose a model of production cost advantage based on the internal organization of partners in construction business. In this sense, my work is an extension of [13]. While they develop a description of the interactions between TCE and production costs, I concentrate on the development of a formal, rigorous model of the production costs. My formal model could then be compared to TCE in the same way as Gurbuxani and Whang compared agency predictions to TCE. Separately, my model could be combined with a formal model of transaction costs to develop a more thorough understanding of the procurement interactions in construction business.

The idea that organizational form creates resources is not new. Coase [9] suggested that there was some resource generated simply by organizing as a firm, which provided advantage over a market. Similarly, Williamson [18] expanded on this idea and showed how M-Form organizations might have resource advantages over U-Form organizations, simply by virtue of the form. Maskin, et al. propose that the distribution of shocks can be mitigated by a choice of the appropriate organizational form [17]. Barcena-Ruiz and Espinosa [3] show that the incentive scheme of a firm depends on whether the goods it produces are complements or substitutes. In this model, firms chose between U-form and M-forms of organization specifically to allow them to provide the proper incentives to managers. However, such an assumption does not explain what the scale economies arise from, and such an assumption is often unwarranted as "…most large companies have the critical mass required to achieve economies of scale. [15, p. 169]".

The focus on production cost aspects is particularly salient in the context of archetypical outsourcing. This is true because the relevant question is not whether to organize the IT department within a hierarchy or as an independent entity. Rather, the question is whether to organize the IT department within one hierarchy over another hierarchy. Thus, many of the TCE considerations relative to internal organization will remain constant. For example, of the three categories of transactions costs that limit firm size—bounded rationality, bureaucratic insularity, and atmospheric consequences [18]—only the atmospheric conditions are likely to be systematically different between partner firms and focal owners in construction business. At the same time, all of the TCE considerations based on non-integrated transactions are present. Thus it becomes especially important to explain some production based advantage of IT providers.

3. The Model

A firm is a collection of different units, usually arranged either by objective or by function. Specifically, communication is more efficient within a firm than across firm boundaries. I normalize the ability to communicate externally to zero, so that the only information available to the firm is information about its internal units. In the sense of the model presented here, a firm is an imaginary envelope that traps information. In IT related tasks in construction management this is reasonable assumption.

Each unit in construction business has one employee, who produces the output of the unit. In the case of the IT department the employee is the developer. The goal of the firm is properly to give incentives to this employee to put forth some level of effort, *e*, that generates output, *y*. These incentives are not necessarily monetary, but also occur in the form of promotions, awards, or a good word. For the purposes of this paper, motivating the employee is the same as motivating the unit. The problem is that the output of the functional area is only imperfectly correlated with the manager's effort. Thus, the observed output of functional area *j* in firm *k* is:

$$y_{jk} = e_{jk} + \varepsilon_{jk}, \tag{1}$$

where ε_{jk} is assumed to be normally distributed with a mean of zero and a variance of σ^2_{jk}.

Equation (1) suggests that not all of the output of a given unit is directly under the control of the unit employee. Software may be buggy, systems machinery can fail, or users can fail to adopt. Further, IT professionals in construction business are much like knowledge workers than other physical workers and as such, much of the work they do is unobservable [11]. Thus the effort level cannot be directly observed and the incentive can depend only on the observed output, *y*. This makes sense for IT because much of the manager's effort involves intangibles that are invisible to the end user, but that certainly effect usability. Thus I present a standard agency problem in which the principle cannot observe the agent's effort. To this, I add the additional innovation that output is not a perfect indicator of effort. The problem of the construction firm is to choose an incentive scheme, $i(y_{jk},y_{lm})$, to best motivate the risk adverse manager to perform. The only difference between a focal owner and its partners is the information available to them in the form of output data. A construction firm can be considered as a set $F=\{y\in y_{jk}\}$, so that a construction firm is a set of outputs, and the construction firm can use those outputs to structure incentive schemes.

The employee must choose the level of effort to maximize his utility subject to the incentive offered by the construction firm and some disutility of effort. This choice can be represented as:

$$\max_{e_{jk}} U(i_{jk}(y_{jk}, y_{lm})) - D(e_{jk}), \tag{2}$$

Thus, the employee's utility is based on his output relative to another employee and the cost is based on actual effort. Cost of effort is assumed to be increasing. The construction firm's problem is to choose a set of incentives to motivate employees to undertake the profit maximizing level of effort. This can be represented, in the two employee case, as

$$\max_{i_{jk}, i_{lm}} \left(\left\lfloor y_{jk} - C(i_{jk}(y_{jk}, y_{lm})) \right\rfloor + \left\lfloor y_{lm} - C(i_{lm}(y_{jk}, y_{lm})) \right\rfloor \right), \tag{3}$$

Thus, the construction firm chooses the incentive schemes that induce the employees to produce outputs, which are construction firm's revenues. However, the construction firm must pay the cost of these incentives.

For parsimony and generalizability assume two functions (IT and Other) and two construction firms (1 and 2) yielding four outputs (y_{IT1}, y_{IT2}, y_{o1}, y_{o2}). Assume that each unit receives its own shock denoted by $\varepsilon_{ObjectiveFunction}$. I define a focal owner as a construction firm that manages multiple different functional areas with the same objective. I define the partner as a construction firm that manages multiple identical functional areas with different objectives. In this case, construction firm 1 is the focal owner. The question then is which organization can structure a better incentive for the IT manager in construction firm 1. If IT is insourced then the incentive for the IT manager is based on the output of the IT manager of construction firm 1 (y_{IT1}) and the output of the other manager in construction firm 1 (y_{o1}). If IT is outsourced, the incentive is based on the output of the IT manager of construction firm 1 (y_{IT1}) and the output of the IT manager of construction firm 2 (y_{IT2}). Thus, the incentive offered by the focal owner to the IT manager is:

$$i_1(y_{IT1}, y_{o1}), \tag{4}$$

and, the incentive offered to IT manager by the partner firm is

$$i_{IT}(y_{IT1}, y_{IT2}). \tag{5}$$

It can be shown that if employee *o1* of the focal owner exerts a level of effort *e**, then an incentive scheme can be designed by the partner firm such that if employee *IT2* of the partner firm exerts a level of effort *e**, then $i_{IT}(y_{IT1}, y_{IT2})$ is equivalent to $i_1(y_{IT1}, y_{o1})$, in that $i_{IT}(y_{IT1}, y_{IT2})$ motivates the developer to exert at least as much effort as $i_1(y_{IT1}, y_{o1})$. However, this result rest on the assumption that

$$\mathrm{Var}(\varepsilon_{IT1} \mid \varepsilon_{IT2}) < \mathrm{Var}(\varepsilon_{IT1} \mid \varepsilon_{o1}). \tag{6}$$

The assumption in (4) implies that if the measurement error of an IT manager’s effort is less given the measurement error of other IT managers in different construction firm, than given the measurement errors of other functional areas in the same construction firm, then the partner can provide incentives at least as good as the focal owner, and thus operate the IT department at least as efficiently. Outsourcing will be a good solution when the variance among construction firms is less than the variance among functional areas. This means that the IT function in a construction firm is more similar to the IT function in other construction firms than it is to non-IT functions within the same construction firm. If variance among functional units is taken as fixed this leads to the following Proposition:

Proposition 1: If Var ($\varepsilon_{IT1} \mid \varepsilon_{IT2}$) < Var ($\varepsilon_{IT1} \mid \varepsilon_{o1}$) then for any incentive scheme $i_1(y_{IT1}, y_{o1})$, based on the output of the focal construction owner’s IT unit and the other unit of the focal owner, resulting in effort level e_{IT} on behalf of the developer; the partner construction firm can find an equivalent scheme $i_{IT}(y_{IT1}, y_{IT2})$ based on the output of the focal owner's IT unit and the output of the partner's other IT unit, that would result in the same effort level e_{IT} on behalf of the developer.

What the Proposition indicates is that the partner construction firm can encourage at least the same level of effort in its employees as the focal construction owner. This is the case, no matter how complex the focal owners' incentive schemes may be. This powerful result hinges on the conditional variances, so the reverse case (that the focal owner can duplicate the partner firms' incentives) does not hold. The idea that partner construction firms focusing on specific functions rather than overall objectives can offer better incentives to employees is supported in the literature. Lacity and Hirshheim [14] provide a number of case studies in which managers indicate that they expect IT personnel to have better opportunities when transferred to a partner firm. The actions of the employees seem to support this, because they typically transfer to the infrastructure partner rather than seek employment in another manufacturing type firm.

Proposition 1A: If Var $(\varepsilon_{IT1} \mid \varepsilon_{IT2})$ < Var $(\varepsilon_{IT1} \mid \varepsilon_{o1})$ then it is not necessarily true that the partner construction firm can find an equivalent scheme based on the output of the same function in other objectives that results in the same effort level e_{IT} on behalf of the IT manager.

Proposition 1A is a restatement of Theorum1 that provides important insight into the understanding of interorganizational partnerships. Proposition 1A states the boundary conditions under which the focal construction owner may not expect a relationship to be advantageous. If a partner construction firm cannot bring additional information with which to gage the productivity of functional employees then it is not able to provide superior incentives to those employees.

It is important to consider the conditions that would cause Var $(\varepsilon_{IT1} \mid \varepsilon_{IT2})$ < Var $(\varepsilon_{IT1} \mid \varepsilon_{o1})$ so that the partner construction firm would have superior evaluative information than the focal construction owner. An obvious candidate condition is that the partner construction firm performs substantially similar activities across a number of similar objectives. This is the typical concept of firm specialization. The innovation offered in this case is simply to explain the source of the value of specialization. Rather than appealing to the idea that some construction firms are simply better than others, I propose that it is because of the information inherent in the construction firms' organizational structure.

Another possibility is that there are functional and objective shocks. Functional shocks would be those shocks that occur to all units in a specific function, while objective shocks would occur to all units with a similar objective. A perfect example of a functional shock would be a change in legal reporting requirements that required rework of financial software. Thus, the financial reporting function would be impacted across multiple objectives. An example of an objective shock would be cyclical variation in the objective area, like Christmas. Given these types of shocks, the observed output of a manager would be

$$y_{j,k} = e_{j,k} + o_k + f_j \,. \tag{7}$$

This characterization shows that the observable output of a unit manager is a function of his effort plus the shock to the objective plus the shock to the function. The focal construction owner would know the o_k while the partner construction firm would know the f_j. The conditional variance of the unit manager from the focal construction owner's point of view would be the variance of the f_i's and the conditional variance from the point of view of the partner construction firm would be the variance of the o_k's. Thus, the variance condition for Proposition 1 becomes Var(o) < Var(f). Thus, when shocks to IT infrastructure are larger than shocks to business objectives of construction firm, it makes more sense to form partnerships with the partners in order to control the variance. Another useful case to look at is the limiting case where output is observable without error. It is obvious that

Proposition 2: $\lim_{Var(\varepsilon_{IT,1})\to 0} Var(\varepsilon_{IT,1} \mid \varepsilon_{IT,2}) = \lim_{Var(\varepsilon_{IT,1})\to 0} Var(\varepsilon_{IT,1} \mid \varepsilon_{o,1}) = 0 \,.$

Simply stated as the output of a certain unit in construction firmbecomes more accurately observable, the value of using relationships over internal management decreases to zero. This implies that partnerships provide no special value for highly standardized, easily observable tasks in construction business. This seems a contradiction to the standard wisdom, which suggests that firms should outsource the mundane, commodity like tasks and keep in-house the unique tasks. However, the result above is symmetrical in the sense that it suggests that keeping tasks in-house provides no special advantage, too. Thus, other considerations must be used to make the decision. If there are significant economies of scale, for example, construction firms may very well want to offload a mundane task to a partner. On the other hand, if there are significant transactions costs, a construction firm may choose to keep such a task in-house. The point is that if two construction firms are otherwise equal, then it does not really matter where a mundane task is handled. This intuition makes more sense than the typical prescription that firms should always outsource these types of tasks.

4. Specific Example

Basing an employee's compensation on the output of another employee boils down to a situation wherein, whoever works the hardest gets a reward. There can be variation in the actual mechanism in construction. For example, handicapping might be used, so that one employee would have to work some amount harder than the other. However, the basic premise is well represented by a model in which whoever works harder gets the bonus. Thus, I illustrate the model with that example. Assume that the only incentive scheme available to each construction firm is offering a lump sum reward with a value of one, and that reward is offered to the employee with the greatest output. This could represent a promotion, a bonus, a corner office, or any other reward. Mathematically this is expressed as

$$i_{jk}(y_{jk}, y_{lm}) = \begin{cases} 1 \, if \; y_{jk} > y_{lm} \\ 0 \, if \; y_{jk} \le y_{lm} \end{cases} \qquad (8)$$

Further, assume that the utility of this reward is also one, and the utility of no reward is zero. The developer takes the other employee's effort as given, so he sees the expected utility of a given level of effort as the normal cumulative distribution function (CDF). The employee's decision then reduces to choosing the level of effort where the marginal increase in expected utility as a result of effort is equal to the marginal cost of effort. When the developer works for the focal construction owner the CDF from which he derives his benefit has a greater variance than the CDF from which he would draw his value if he worked in the provider firm. This is illustrated in Figure 1.

As Figure 1 illustrates, the provider firm is able to offer better incentives to the developer, so that the developer exerts more effort. Incentive costs and benefits are held constant, and yet the developer working for the provider firm put for effort equal to P, while the same developer, if working for the focal construction owner, would put forth effort level F, which is less than P.

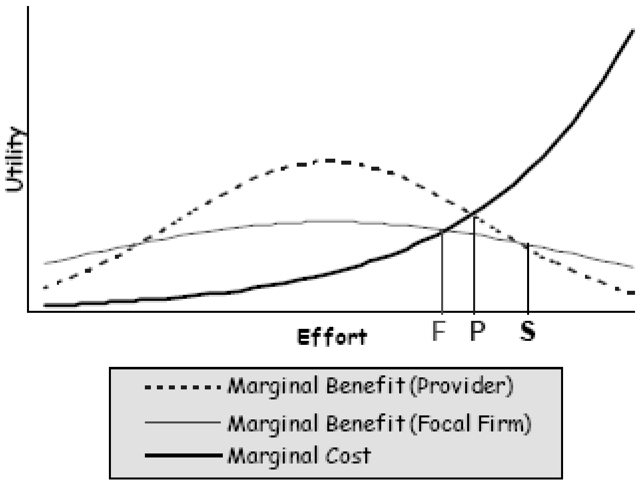

Figure 1: Employee's Effort Choice

The more interesting insight offered by Figure 1, is that beyond effort level S the effort level induced by the focal construction owner's higher variance incentive actually induces greater effort. The intuition here is that as effort becomes more observable, the harder worker is more certain of winning the reward. Thus, engaging in extra effort to insure winning becomes less valuable. At the limit, with complete observability of effort, the developer would only work until he had surpassed the other employee. This seems like a contradiction to the Propositions developed earlier, but it is not. The important factor to understand is that the provider firm can introduce variance into its observations, so that beyond point S it mimics the CDF of the focal construction owner. This means that the provider firm purposefully chooses to ignore some of the output information, and by doing so actually encourages greater effort. The important, and pleasing, take-away is that more information is not necessarily better. This is a well known view in the IS literature [2], but goes against the grain of many economic models.

5. Conclusions

Interorganizational relationships focused on IT are an ongoing concern of most construction firms, and an important research question to academics. However, neither academics nor practitioners have satisfactorily explained the fundamental premise of procurement—that the partner construction firm is better than the focal construction owner at providing IT services. Not only must a partner construction firm be better, but also it must be superior enough to justify the very real expenses associated with IT outsourcing. Armed with a better understanding of the circumstances under which the partner construction firm is, in fact, superior, focal construction owner will be better able to make the initial step in deciding whether outsourcing is even a viable option.

I have presented a model that proposes why an outsourcing partner construction firm might perform better than a focal construction owner might. The model contains several innovations. First, the source of the advantage (the resource) was not exogenously assumed, but rather derived as a property of the organization structure of the partner construction firm. This allows for a richer description of the resource, including the boundary conditions where the resource might not be present. The second innovation is in the richness of the analytical model. Whereas standard agency theory models focus on a very small range of incentives—usually commission verses salary—my model focuses on the ability to generate any incentive. This is certainly more realistic in the case of IT professionals who are frequently paid in stock options, which are computationally much more complex than a simple commission usually provided by many construction firms.

A third advance of the model was to hold constant both economies of scale and IT managerial talent, and explain how a purely organizational explanation of procurement advantage could arise from differences in the type of information available to construction firms. A forth contribution of this work is to offer an introductory attempt to join classical economics to transaction cost economics, recognizing not only the costs of transacting, but also the relative production cost advantages of different construction firms. To this end a model is developed that uses the same level of analysis for production as TCE work traditionally uses. Specifically, the internal production costs of a firm are assumed to depend on characteristics of the construction firm, rather than to be the traditional black box. Only by formulating models of transaction costs and production costs at the same level of detail, can researchers hope to reconcile these two viewpoints.

By focusing on the information/knowledge assets available to a partner construction firm I develop an analytical model that shows how information which reduces the variance of observed output allows a construction firm to structure better incentives. The basic intuition is that partner construction firms have access to the output of other functional areas, which are doing the same job. The ability to observe a matched sample gives the partner construction firms an edge in designing incentives. Further, because much of this information is tacit, the partner construction firm cannot simply sell the information to the focal construction owner.

The basic result then is that because the partner construction firm has access to information about similar departments, it can more accurately estimate the IT department's effort and reward accordingly. This result is tempered by the caution that if the other IT departments/projects are dissimilar to what the partner construction firm is able to observe, then that partner construction firm provides no additional benefit. Thus, if either the construction firm itself or the project is unusual there is no benefit to outsourcing in procurement. In addition, if the project is ordinary but very different from what the partner construction firm usually does, outsourcing provides no particular benefits.

Until now, the study of outsourcing has largely put the cart before the horse, going in to great detail about how to manage an owner-partner relationship, without ever asking when a relationship is even appropriate. By establishing these boundary conditions, this paper makes way for a better understanding of procurement success and failure in construction business. This will allow managers in construction business to decide which projects are the best candidates for procurement and which partners are the best candidates for a specific project, before they begin the difficult undertaking of outsourcing a contract to manage the procurement relation.

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Section VI

Industrialization in Construction

Successful Industrialisation, innovation and prefabrication in construction

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Abstract

The construction industry is commonly characterized as one that is labour intensive, with a low level of innovation, of technology diffusion, of technological advancement of on-site construction and thus a low level of industrialization compared to manufacturing. The importance of the construction industry to the national economies is no subject for debate in contrast to its performance -in terms of efficiency as well as quality of output- in many cases. More than often the example of the manufacturing industry is taken to point at opportunities of industrialisation in construction, by application of innovation and prefabrication. The number of rather successful attempts on large scale in construction however is limited. The question mark that comes up refers to the factors that can be considered determining for successful industrialisation processes particularly in the construction industry. The objective of this paper is to end up in a methodology to assess industrialisation in construction based upon which strategies can be formulated to implement innovation, prefabrication and industrialisation in construction. This paper draws on contemporary theoretic views regarding the factors impeding or stimulating industrialisation, innovation and prefabrication in general. It further will discuss the application of these views in the construction industry.

Keywords Industrialisation, Innovation, Prefabrication, Construction Industry

1. Introduction

The importance of the construction industry to the national economies is no subject for debate. Its contribution to GDP, fixed capital formation, government revenue and employment is significant. In terms of production output the construction industry proves to be one of the largest industries. On the other hand construction industry is often blamed for being inefficient, labour intensive, with a low level of innovation, technology diffusion and a low level of technological advancement of on-site construction. More than often the example of the manufacturing industry is taken to point at opportunities of industrialisation to improve the performance in construction, by application of innovation and prefabrication. It is stating the obvious to mention that the construction industry differs in many respects from the manufacturing industries also in the case of industrialisation and innovation in construction. In the following first contemporary theoretic views regarding the factors impeding or stimulating industrialisation in manufacturing will be reviewed. After that we will discuss the application of these views in the construction industry.

2. Industrialisation and innovation

Industrialisation is a rather complex concept. The process of industrialisation in West-European countries involved extensive changes of production systems which resulted in a shift from home-based manual production to large-scale factory production. Industrialisation and socio-economic changes are closely intertwined with technological innovation, particularly the development of large-scale energy production and developments in the field of new materials such as metallurgy, plastics, and polymers [2] "Industry" is hereby equated with the manufacturing sector which comprises establishments primarily engaged in the mechanical, physical or chemical transformation of materials, substances or components into new products. The production systems in manufacturing changed through mechanization, systematization, standardization, automization and flexibilization of the production processes in a sequence of era. In response to the customer's demand for more variability of the production output the production processes became more flexible with a movement towards reaching a higher quality of output and the production of finished products of different kinds.

The conclusion is that in manufacturing sectors industrialisation could have taken place thanks to *innovation.* Innovation is not only the *invention* -i.e. the development of new technologies (products and production processes) and knowledge-, but also the *diffusion* (acceptation, adoption) and *application* of these in manufacturing sectors that enhanced the changing production characteristics over time. [16].

A key question that should be raised now is: What were the major factors that enhanced the invention and diffusion of new technologies and knowledge which made manufacturing sectors industrialise?

3. Theoretical approaches towards industrialisation and innovation

The answers to the question above have been a subject for research by many scholars already since a long time. The role of innovation in improvement of production performance and competitiveness has developed considerably over the past decade in economic literature. In neoclassical economic theories the basic assumption is that a motivated *profit-maximizing, cost minimizing and output maximizing* entrepreneur has to make choices among various production technologies in a perfect competition environment. [18] The neoclassical theories however could not offer a clear insight on the content and process of innovative activity or on the existence of persistent differences in the volume, scope and quality of innovations across firms, sectors or countries. [17] In these views the ultimate incentives are economic in nature; but economic incentives to reduce cost always exist in business operations and precisely because such incentives are so diffuse and general, they do not explain much in terms of the particular sequence and timing of innovative activity. Incentives thus constitute only a necessary condition for innovation. The traditional theories in the field of economics have traditionally had difficulties in addressing issues surrounding technological change. This is also due to the special nature of technology. Technology and knowledge are seen as a system of interrelated know-how, skills and knowledge (know-why, when, where and by whom) regarding production processes and products. Technology and knowledge that is general and widespread to the industry and is partially un-codified is seen as public good. Firm-specific technology and knowledge that is often patented, protected, or secret is seen as private good is not freely available. [19] In recent years, both extensions of the neoclassical theory (e.g., new growth theory), as well as alternative approaches to this dominant paradigm have emerged, including the broad field of evolutionary economics. The core concept in these theories is the innovation within technological paradigms. The theoretical approach often draws on Thomas Kuhn's seminal thesis (1962) in which the word *paradigm* is introduced. [10] This relates to. social constructs -a pattern- made of knowledge, rules, conventions, consensual expectations, assumptions, or thinking which characterize professional practice. A *paradigm shift* is a significant, profound and irreversible change from one fundamental view to another, a different model of behaviour or perception. It can be either evolutionary (i.e., a slow pace of change) or revolutionary-dramatic, short-term, and immediate high impact. Innovations -technological and knowledge developments- can thus bring about a paradigm shift. However innovation processes do not take place in isolation. [3]. Nelson & Winter's (1982) stated that sectoral asymmetries in industrial dynamics and innovativeness can be interpreted on the grounds of technological regimes [14] A technological regime defines the particular knowledge environment where innovation (problem-solving activities by firms) take place [23]. In this sense technological regimes (a set of rules that guide the design and further the development of a particular technology) sets the boundaries and form a constraint to what can be achieved in innovative activities associated with a given set of production activities, and the directions (natural trajectories) along which solutions are likely to be found [12] Malerba & Orsenigo (1996), Breschi *et al.* (2000) define technological regimes as a particular combination of four factors - technological opportunity, appropriability of innovations, cumulativeness of technological advances, and properties of the knowledge base- as being common to specific activities of innovation and production and shared by the population of firms undertaking those activities.[11]; [1] *Technological opportunities* indicate the likelihood of innovating for any given amount of money invested in search. High opportunities are to be found in an economic environment that is not functionally constrained by scarcity. This situation provides powerful incentives to the undertaking of innovative activities, thus potential innovators may come up with frequent and important technological innovations. There also is a policy and regulatory environment that might form either an opportunity or a constraint to innovation. *Appropriability of innovations* indicates the possibilities of protecting innovations from imitation and of reaping profits from innovative activities. High appropriability reflects the potential to successfully protect innovation from imitation by means of patents, secrecy, lead times, costs and time required for duplication, learning curve effects, superior sales efforts, and differential technical efficiency due to scale economies. *Cumulativeness of technical advances* reflects the existence of a technology and knowledge base that forms the building blocks for future innovations. Based on existing technologies and knowledge a stream of subsequent innovations can be generated that are incremental changes of the original one, or it may create new knowledge that is used for other innovations in related areas. Economic environments characterized by continuities in innovative activities and increasing returns are considered to have high levels of cumulativeness. The last is also related to the cognitive nature of the learning process (e.g., learning by doing). The *property of the knowledge base* relates to the *nature* of the technology and knowledge that is available to support innovative activities. Technology and knowledge can be classified in various ways: generic versus specific; public vs. private; degree of complexity, tacitness etc. Previous literature mainly focuses on specificity, i.e. specialized and targeted to specific applications. [1] The level of specificity reflects that knowledge can be universal and widely applicable, or more specific to particular ways of doing things. The knowledge base is to be found in a network of more or less interrelated enterprises institutions and organisations that all together form the industrial *innovation system*. The opportunities to innovate depend on the extent to which an industry can draw from the knowledge base, the technological advances of its suppliers and customers, and major scientific advances in universities and R&D institutes.

Conclusion Industrialisation in manufacturing thus could have taken place thanks to a sequence of innovations. Innovativeness of industries highly depends on technological regimes and the characteristics of the innovation system.

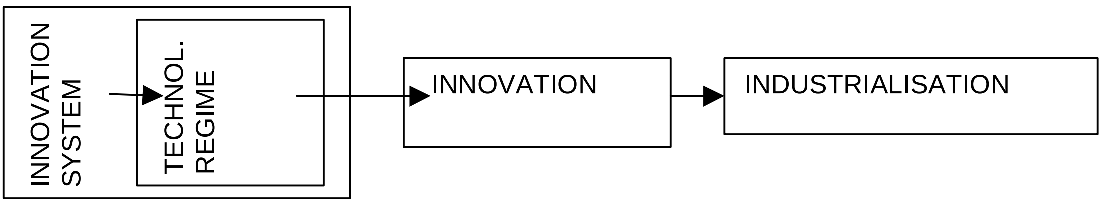

Figure 1: Factors influencing Industrialisation and innovation

4. Construction industry

In line with the definition for manufacturing one could state that construction is the transformation of materials, substances or components into buildings and infrastructural works. A building construction process can be seen as a complex multi stage production system. Each of the stages involves a production process in which intimately related interactions take place between various parties:

(a) Product development stage; planning, design, engineering, specification;
(b) Process development and production stage, which includes determination of the construction system, construction planning, work breakdown, work packaging, the schedule and layout of the construction site, organisation structure, cost estimation, tendering, preparation, transformation and assembly of materials, components for physical realisation of a building. cost and quality control;
(c) Production process stage of the building materials, elements and components. [4]

In traditional building construction processes in the past, but also still in developing countries at present, the production process of building materials, elements and components takes place on the building site and thus is integrated in the stage of actual realization of the planned building. The lack of alignment between the parties working side by side on construction projects translates into dysfunctional teams, poor levels of cooperation and lost opportunities for the optimum use of resources, innovation and industrialisation.

5. Industrialisation, innovation and prefabrication in the Construction Industry

The construction industry is commonly characterized as one that is labour intensive, with a low level of innovation, of technology diffusion, of technological advancement of on-site construction and thus a low level of industrialization compared to manufacturing. Industrialisation is expected to reduce costs through faster construction, to increase construction quality, to eliminate dependence on weather conditions at the construction site, and to improve coordination of planning and construction. Viewing building construction as a total production system, sub-divided in a number of individual production processes, implies that each of these processes has a potential to be industrialised. This means that innovations can be applied in (a) the process of design, engineering and specification of the construction; (b) the process of project execution, i.e. the actual building process; (c) the process of building materials, elements and systems production as well as integrated in the total construction process. CIB W24 (International Council for Research and Innovation in Building and Construction, Work group 24) defined Industrialised Building as "a building technology where modern systematised methods of design, production planning and control as well as mechanised and automated manufacture are applied". Industrialised building, following the views applied to industrialised manufacturing, should relate to the application of accumulated knowledge and technologies in construction processes that become increasingly mechanized, rationalized, systematized, standardized, automatized and flexible. Industrialised building does not necessarily equate with mass production. Mechanization in parts of the construction process on site and prefabrication of building materials and elements were the first phenomena of industrialisation in the construction industry with the purpose to reduce costs of manpower and time-consuming activities. What actually has happened in the construction industry in the course of time is that combinations of innovative solutions based on accumulated technological and knowledge advances were adopted in attempts to move from largely craft-based construction to a systematic construction process where resources are utilised efficiently. In fact a *convergence of technologies and knowledg*e from different areas and disciplines has taken place. By drawing parallels between industrialisation in manufacturing and construction like Girmscheid and Hofmann (2000) did, the sequence of accumulated knowledge and technology advances as well as their impact on the construction process characteristics can be noticed as outlined in table 1.

Table 1 Innovation and changing construction process characteristics
Sources: based on Dicken (2000) and Girmscheid & Hofmann (2000)

Era	construction process characteristics	Cumulative technology & knowledge advances
craft based construction	- location-bound - labour + division of tasks - building materials and constr. system determined by availability of natural resources	Materials Product engineering
Mechanization	- Labour substituted by machines - New materials - Prefabrication of building materials & elements	Materials Product engineering Energy Transport
Rationalization Systematization Standardization	- New materials and composites - Standard bld elements & engineering solutions (e.g. components, methods, processes or dimensional standardisation and modularisation) - Pre-assembly (materials, prefabricated components and/or equipment are joined together for subsequent installation); - Modular and dimensional coordination - Work process organization further division of tasks - More control and supervision	Materials Product engineering (based on applied mechanics & building physics; new mathem. tools) Energy Transport Production management
Specialization Automization	- New and engineered materials, (e.g. high strength concrete, fibre reinforced materials, glass, ceramics) - Assembly line production processes of standard bld elements with flexibility in design - More control on pace of production - Mass production: large volumes of standardized products - Large span and tall buildings - Building systems (a product system with an organised entity consisting of components with defined relationships, including design rules) - Construction management - Optimization of procurement & logistics - Lean construction - Concentration on market segments	Materials Product engineering Transport Energy Production management Process engineering
Flexibilization Integration	- Utilisation of programmable machines (e.g. robots-performing tasks; computerised tools for planning, design and operation; computer added management) - Flexibility in standardized elements and bld systems - Intelligent buildings - Interaction of design, engineering, planning, production, construction and marketing - Integration of planning, construction, manufacturing and marketing - Response to dynamic market demand: (mass customization) >relation/communication suppliers-producer-user-	Materials Product engineering Transport Energy Enterprise management Process engineering ICT

Innovation in the construction industry refers to the process of development, distribution and application of technologies -a new or improved product, process or service- and knowledge with the purpose to improve productivity and to suit the customer's requirements. Construction industry innovations are mostly incremental and thrive on accumulated technological and knowledge advances and took place in various areas: materials, engineering, transport and equipment, ICT, computers, robotics and management. As construction evolves into an industrialized process, new construction methods and building systems are also being developed to assemble prefabricated components. "Prefabrication" existed already in the ancient world; in Egypt, Greece, and Italy, where famous buildings were erected with prefabricated components made of stone [22]. The past decennia have seen the popularity of prefabrication rise and fall. At present it still gets a mixed acceptation. Despite this it is widely applied in modern construction and became almost normal practice. The benefits of prefabrication, or off-site fabrication, as making a significant contribution to construction performance, are increasingly recognised by the construction industry. The advantages of prefabrication include a reduction of (time-consuming) on-site activities and an elimination of some of the construction peculiarities such as suboptimal (climatological, locational) site conditions. On the other hand the introduction of prefabrication in the construction process tends to make the total process more complex. Prefabrication means investing in preparation, so that things proceed smoothly. Planning and organization must be intensified, of interaction, cooperation and co-ordination in a multi-trades context has to be optimized. [9]. This also implies a need to have a quality control system for all activities during the whole process since the requirements on dimensional tolerances are more severe. The degree of industrial prefabrication has an impact on competitive prizes. A higher degree of prefabrication on the other hand, requires more work on the part of planners, which means that more time must be invested in planning processes. There is a necessity of making precise commitments in certain instances in the planning process. According to Warszawski [22], the main problem of prefabrication today is the lack of a system approach to its employment among the diverse parties involved.

Industrialised building did not automatically imply increased productivity, reduction of man-hours, or economic growth. To provide high performance buildings to the consumer, profit maximization, cost minimization and output maximization to builders, production theories and management tools were used in order to know how to manage their operations in all phases. Koskela and Vrijhoef [8] note that direct application of radical managerial innovations such as mass production or lean production from manufacturing. to construction has been limited due to different context in construction in correspondence to manufacturing. The question is whether the evolutionary theoretic approach will offer a better understanding of the major factors that are impeding or stimulating industrialisation, innovation and prefabrication in the construction industry and thereby a better insight in the strategies to be followed to industrialise.

6. Innovation system, technological regime and paradigm shifts in construction industry

The next paragraph tries to describe innovation and industrialisation in the construction industry following the lines of thought of the theories that were discussed in the foregoing. The assumption is that the innovation system comprises incentives for innovation and paradigm shifts provided (or constraints formed) by the technological regime, i.e. the economic and regulatory environment, the internal capacity of firms to seize market and technological opportunities; cumulativeness and nature of technological and knowledge advances; accessibility of critical inputs and the way new technologies and knowledge is protected for imitation. *The innovation system of the construction industry* includes a variety of actors. It is the network of more or less interrelated enterprises, organisations and institutes which jointly and individually contribute to innovation, i.e. to the development, diffusion, application and use of new technologies. *Longterm linkages* between the various actors are critical for innovativeness and for the efficiency in terms of speed and costs at which projects and technological inventions in these are realised, handed over and used by and among the actors. It counts also for the efficacy at which clients requirements are met with the project. Linkages in the construction industry however are mostly project bound and of temporary nature. It is not only the linkage that counts it is also the *size and nature of the knowledge base* within the distinct institutes, organisations and firms that is considered determining for innovation and industrialisation. The construction industry is characterized by a high percentage of small and medium sized firms. Much of the technology and knowledge – at least in the contractor business- is tacit, not codified and project experiences are often not documented, which makes diffusion more problematic. Building product and material manufacturers have been the major sector of the construction industry to actively develop or look for new technology to improve their products, given the fact that they can profit from scale economies, which forms an *technological opportunity*. Another industrialisation *stimulating factor* concerns the aging and shrinking construction labour force in many Western countries as progressively fewer young people enter the industry. If demand for labour remains the same and the supply decreases, costs will increase. This pressure will lead builders to innovate and apply industrialized construction, which requires fewer specialized trades and people. *Impeding factor* is the tendency to conservatism making that diffusion of technological developments - a new or improved material, building element, process component or procurement method - generally faces quite some constraints within the construction industry. The array of regulations and standards -often unduly conservative and prescriptive- as well as the variety of contractual agreements and the separation of responsibilities among those involved in a construction process can be blamed for this. [13], [15]. The reluctance to change is enhanced by risks of unforeseen failure and damage during the project execution and a marginality of profits. Acceptance, application and implementation of technological developments, inventions and improvements in the construction industry therefore slowly come to pass. An important role for Governments is to improve the efficiency of innovation systems and facilitate their formation. Innovation stimulating is the fact that people become more educated and know more about for instance energy conservation, lighting, indoor air quality, and other health and comfort related issues, consumers (homebuyers and commercial property owners). These customers put pressure on firms to deliver better quality goods and services. The uniqueness of each construction project provides an impetus for innovation. Moreover *appropriability in construction is low*; construction operations are rather transparent, easy to copy and have the opportunities for job-site training; the industry has an extensive scope for diffusion of inventions and technological improvements from other projects and industries. [7], [20]. Although there are incentives to innovate and industrialise, there are factors impeding innovation and industrialisation which in majority appear to be the deficits in the innovation system such as cooperation between planning and construction as well as characteristics of the technological regime such as the reluctance to accept and adopt new technologies.

7. Conclusion and discussion

In this paper the theories that could underpin our understanding of industrialised manufacturing have been discussed as well as how these can be utilized to improve our understanding of what happens regarding industrialisation in the construction industry. The innovation system approach as developed by economists (Malherba, Nelson and Winter) seems to offer an interesting opportunity to get a grip on the processes of industrialisation in the construction industry. The basic assumption that is adopted here is that the technological regime of the construction industry sets the boundaries for innovations, which applied in this industry stimulates or are an constraint for industrialization processes. The construction industry has continuously developed during the years. Innovations could develop by accumulation and convergence of technologies and knowledge from various areas and different parties in the construction industry in the course of time. Despite this the technological regime and the innovation system seems to adversely affect innovation and industrialisation. More transparent forms of planning cooperation could be a way forward as well as innovative forms of communication and/or exchange between planners and builders. The development of integrated production management in the construction industry - of which development prefabrication is a part- supported by ICT development and application, is expected to lead to industrialised building and at the same time will bring about radical changes for the involved firms. It still is point for discussion what exact type of paradigm shifts is needed for real successful industrialised construction.

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Industrialization in Building Construction – Production Technology or Management Concept?

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Abstract

So-called "Industrialization in Construction" is always presented as the ideal solution when the problems facing the construction industry take on survival-threatening proportions.

Hope centres on solving these problems by using state of the art on- and off-site production technologies and standardized products, elements, and modules, but this approach ignores the fact that the problems facing the construction industry are caused by fundamental structural economical deficits, which cannot be overcome simply by implementing measures such as these. Past experience has shown that attempts to "industrialize" the construction process have failed time and again, since such efforts always focus on the production aspect. The following paper attempts to demonstrate the real consequences of rigorously industrializing the construction processes, whereby production-related measures, such as automation or standardization, are not, on their own, the deciding success factors. Success depends on the ability to combine these measures, both with a product-oriented and customer-oriented approach, and the industrialized organization of all production and planning processes.

Keywords: industrial construction, project delivery model, system provider

1. Introduction

1.1 Status quo

A survey of cost structures in building construction [4] shows that the total construction costs account for only approx. 50 % of the total investment costs of a residential building (Table 1). Depending on local land prices, however, this share may differ to the high or to the low side. In the light of industrialization, however, the construction industry can influence the construction costs. However, Table 1 shows that the costs caused by the production process costs (wages, use of equipment, construction methods) amount to approx. 50 % of the construction costs, and can be influenced by industrialization of the production processes.

Table 1: Distribution of Construction and Investment Costs to the Cost Groups [9]

Cost Groups	**Total Construction Costs**			**Investment Costs**
	Share of Manpower / Equipment	Share of Material	Construction Costs	
	%	%	%	%
Land				25 %
Planning / Management			~ 10 %	5 %
Development	70 %	30 %	14 %	
Structure	50 %	50 %	36 %	
HVAC	40 %	60 %	30 %	
Finishings		40 %	20 %	
Construction Costs	~ 50 %	~ 50 %	100 %	53 %
Outdoor Facilities				7 %
Financing				5 %
Marketing				5 %
Total				100 %

The potentials of economies and efficiency respectively, which are immanent to the construction cost group, can be classified as follows:

- Increase of the efficiency of the production processes and methods
- Elimination / reduction of working hours lost due to inclement weather
- Elimination / reduction of weather-related fluctuations in performance
- Increase of efficiency by clear work flow processes
- Elimination / reduction of searching for material
- Elimination / reduction of rearranging material
- Reduction of loss of material

This would increase the value-adding activities during production and, to a large extent, eliminate the non value-adding activities (Figure 1).

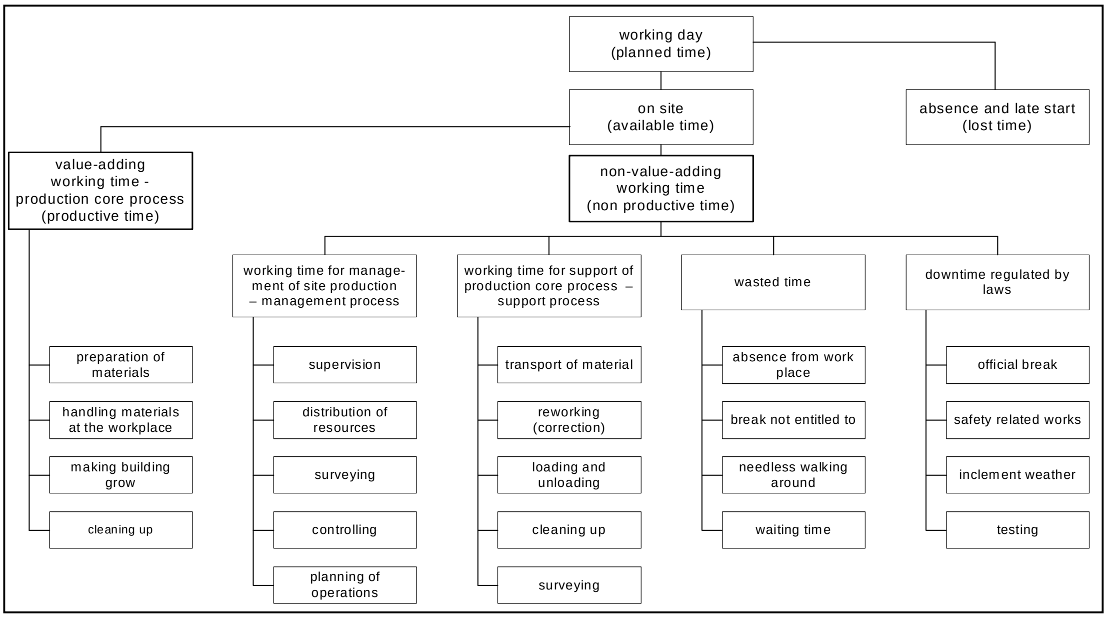

Figure 1: Systematization of working time on a construction site [14]

Boenert and Bloemeke[[2] show in a survey of building construction sites with largely parallelised structure, technical installation and finishings activities that approx. 33 % of the hours are used for non value-adding work as searching for, and rearranging of, material, which shows potential for an increase in efficiency. Potential for increasing efficiency on traditional construction sites has also been identified by Winch [14].

Not only the pure service provision process but also the support processes (Figure 2) in an enterprise can be organised in a more value-adding way by industrialisation. Potentials in the support processes arise, among others, from procurement [5] and knowledge management [3], [12] as well as from the production planning. At the time being, however, it can be ascertained in some economically important countries of the EU that the traditional, largely manual, individual on-site production is, to a large extent, undamped due to cheap labour from the new member states of the EU and Portugal. However, an adjustment of the wages is to be expected relatively fast. The industrialisation of the construction processes will then gain high momentum to systematically exploit the efficiency potential.

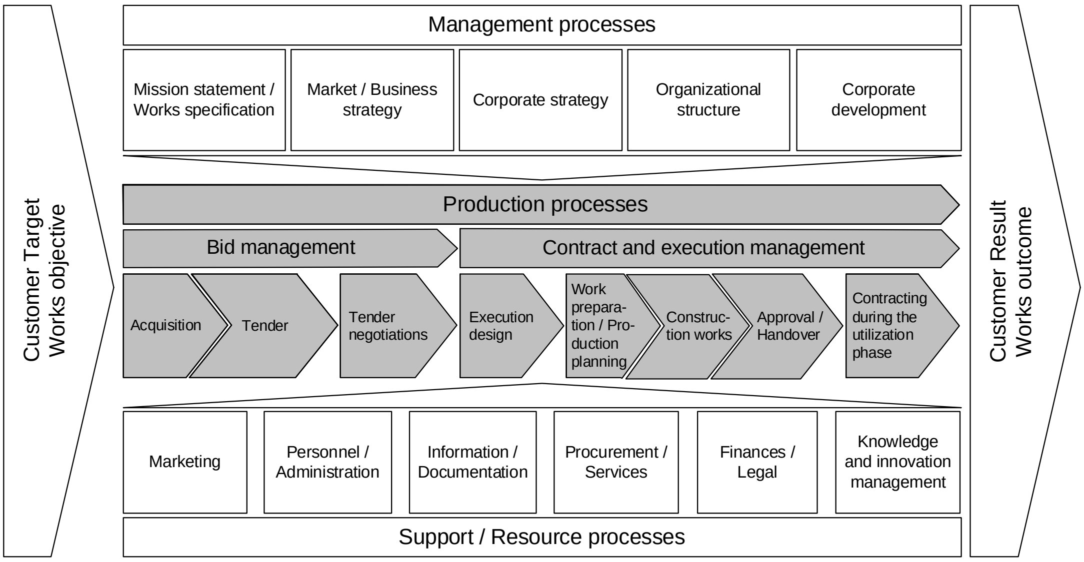

Figure 2: The processes in a construction company

On- and off-site industrialisation of the construction industry will irresistibly make its way, especially in building construction. By developing the tunnel driving machine, the processes in tunnelling have already been industrialised by:

- Mechanization of the work processes
- Logistic systems for supply and disposal in the back-up area
- Automation of the control systems of the tunnel driving machine and the logistic back-up system
- Functional separation of parallelized work processes

As the stationary industry - and not only mass production but also unicum production (e.g. turbines) - has mechanized, computer-aided, and automated its production and service provision processes as stationary in line production and integrated the support processes, a comparison with regard to transferability to construction is indispensable.

1.2 Demands on industrialized construction

A closer analysis of “conventional” industrial production reveals a similarity of the specific characteristics. Taking the particular constraints of construction into consideration, they could, for example, be applied to define the demands on industrialized construction as outlined in Table 2.

Table 2: Characteristics of industrial production and parallels to construction production

Characteristics of industrial production	**Demands on industrialized construction**
Centralized production	Pre-fabrication of components at the factory
Mass production / increasingly variable production	Development of variable basic types
Production based in standardized solutions and manufacture of variations	Standardization of components but still maintaining flexibility of design
Specialization	Focus in specific market segments
Integration of planning, production and marketing	Interaction of building design, production planning, production / construction
Optimized processes and organization	Optimization of the planning and production processes in terms of automation and mechanization

This refutes the frequently sweeping claim that industrial production is not possible in the construction industry on the grounds of its typical situation that cannot be compared with the conditions prevailing in other industries.

Previous attempts to industrialize construction primarily focused on the objectives of replacing manual labour with machinery and automating permanently recurring processes. To be successful, however, any approach aimed at creating industrial structures in the construction industry must extend far beyond these processes, and must lead to process reengineering, or even the establishment of system provision.

Industrialisation of production can be reached by:

- process oriented work preparation and production cycles
- optimized (mechanical / automated) machinery and plant for on-site as well as for off-site production

For implementation in the construction industry, business and cooperation models are required. Industrialisation of construction is a generic process with

- Standardization
- Systematization
- Flexibilization
- Rationalization

Industrialisation has different paradigms (Table 3). Realisation of the different paradigms or their combinations requires collaboration with designers and construction companies of different trades. Further, new project delivery models are required if more standardisation and off-site production is anticipated.

Table 3: Industrialization Paradigms

Paradigms	Process orientation	Design to build	On-site production	Off-site production	product orientation	sustainable product orientation
Measurements	for off- and on-site production: • using work planning and controlling tools to reduce the non-value-adding activities • production flow • logistics	• collaboration / cooperation in design between designer and contractor • standardisation of elements, details, connection • unifying similar elements and details • digital transfer to production equipment and controlling	• work planning • supply planning • work progress control • using mechanical plant • planning off-site logistics • controlling	in factory: • clear sequences of work • independent of climatic conditions • clear work-preparation • work planning • supply planning • using mechanical and automated plant	develop, produce and sell: • clients groups • process oriented production • pamper clients or cost leader • marketing	product is life cycle value oriented: • optimise product in regard to cost- and value efficiency of the life cycle • collaboration / partnering • cooperation • marketing
Marketing strategy / target	cost efficiency	cost efficiency	cost efficiency	cost efficiency	cost efficiency and / or differentiation	cost efficiency and differentiation

In case of product orientation, collaboration and cooperation are required with key designers and trade contractors with core competencies for the product in either case of investment oriented or life cycle oriented construction products. The focus on industrialisation should be in a staged manner, to improve the performance and productivity, and to create continuous improvement for small, medium, and large enterprises. Therefore, the focus is staged in

- improving and rationalizing the work preparation and execution on-site
- incorporating prefabricated products
- producing industrialized on- and off-site structures
- offering to selected client segments off- and on-site construction products

1.3 State of practice in construction production

In order to give the importance of construction production its due, a brief analysis of the state of practice follows, which focuses primarily on the processes found in building construction [9].

When industrialization in construction is mentioned nowadays it is generally linked, above all, to the deployment of computer-aided or computer-controlled equipment. Such equipment is, however, so far only common in partial areas of on- and off-site construction production. Although all levels of industrialised in line production with mechanization and automation, ranging from pure manual production right up to highly automated production plants, are found in pre-fabrication, building site production is still dominated by manual construction using different, mostly non-automated mechanized equipment.

1.3.1 On-site production

The majority of works on building sites are still performed manually to this day. So far neither mechanization concepts, nor and particularly automation concepts, have achieved any widespread acceptance. In the field of masonry construction alone there are first signs of mechanical cogging equipment being used to supplement manual labour, whereas in concrete construction the last major streamlining surge was triggered about 20-25 years ago by formwork systems. Whilst progress in the field of material technology has been ongoing, with a trend towards high-performance materials becoming recognizable, the field of material processing has more or less stagnated.

The development and continuing reduction in size of high-performance and robust DV systems, declining prices for electronic and hydraulic components and the development of service robots, for example, in space, nuclear and underwater technology are providing impetus to continue efforts aimed at automating building site processes. In extreme working conditions, easily programmable and controllable equipment has achieved very high levels of reliability and accuracy, which look promisingly like it could be transferred to building site production.

The real challenge facing on-site production therefore lies in ensuring a working environment and processes that are suited to automation.

1.3.2 Pre-fabrication / Off-site production

During the course of the first wave of industrial automation, which took place back in the 1980s, the first pre-fabricated concrete and masonry elements and modules were also developed for production. Based on in line fabrication processes with a relatively simple structure for the production of concrete pipes, concepts were developed for automated stationary off-site production that were also transferred to the fabrication of elements and modules for residential building construction over time. As such, it would theoretically be possible nowadays to use for the in line production CIM technology to construct a variably designed building completely from elements and modules that had been produced by in line production by computer-aided manipulators and equipment which acts stationary. This would allow a wide range of variability in the architectural design by simultaneously standardizing joints and connectors, reinforcement, wall sections, and, to a certain extent, the material used. The prefabricated elements and modules would then only have to be assembled on the building site with a minimum of effort. Some manufacturers even venture one step further and already offer partially or fully finished building modules like e.g. bathrooms. It is hereby of secondary importance whether the elements and modules are concrete or masonry. Correspondingly automated production machinery is available for both materials, both for use on building sites and for the fabrication of finished elements and modules. Highly-developed production planning and control support for the planning and control of the entire range of fabrication processes are, however, crucial but available in other economical sectors and need to be adapted.

The off-site fabrication of elements and modules in production and assembling lines enables not only the fabrication of simple structural elements but also fully integrated elements and modules with insulation pipes, cables and basic finishing. For the on-site assembling, special joints and connectors are required for the structure and the technical installations. In this case, the prefabricated elements and modules include all the technical and finishing works. The degree of individuality also increases with the resulting decline in the size of the series of the elements and modules (Figure 3).

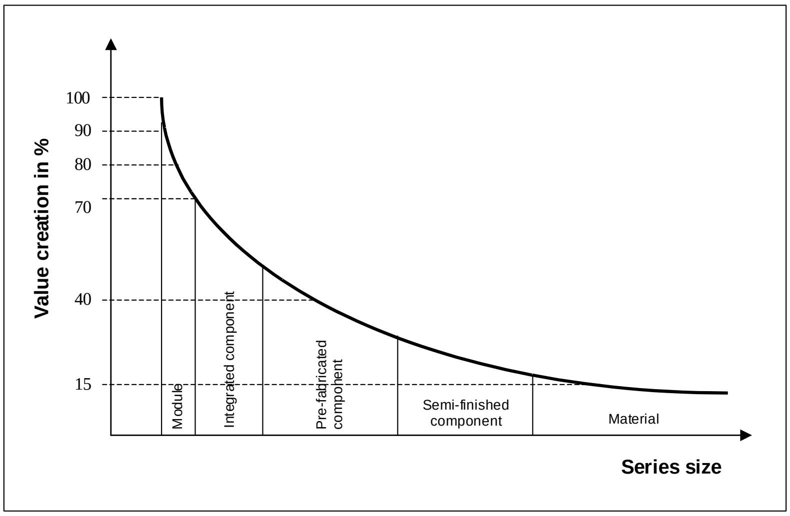

Figure 3: Value creation and series size

1.3.3 Transferring technologies and procedures from other branches of industry

A generalized analysis reveals that the work steps in construction production are very similar to those in other areas of industrial production [10]. The primary categories of work involved are the handling and transport of materials, the fabrication of elements or modules, fittings and connections, the positioning and fixing in the corresponding place, and the prior and subsequent processing steps using special tools. Equipment is already available to handle many of these work steps, and these could be adapted for on- and off-site construction production. One of the characteristics of construction production is the frequent need to work with large and heavy components, elements or modules, which places particular demands on the transport capacity and mobility of placing equipment. Nevertheless, a “peek over the fence” looks promising, given the comparability of the fundamental processes.

2. Consequences for processes and organization

2.1 Means of escaping price competition

The fragmentation of products and services in the construction industry has lead to pure price competition which is one of the primary factors that has resulted in the problems facing the construction industry today. Suppliers and products/services have become virtually interchangeable and replaceable since specific quality attributes are not developed in the manufacturer-neutral planning process. The "classic" structure of a construction contract comprises planning works performed outside the sphere of influence of the construction or prefabrication company with the property developer or owner employing a planner, a construction company, technical installation and finishing companies, whereby the companies have to implement the design in line with technical specifications without being able to accept or analyze the feasibility and optimize the same. All that is important is that the works are offered at a lower price than the competitors and performed within a timeframe stipulated by the client. Any strategy aimed at industrializing construction must therefore include approaches to overcome the fragmentation of planning and construction works, which has resulted in the current situation on the construction market.

2.2 Interactive works and production planning

A strategy aimed at making construction profitable for contractors again must also start at precisely this point. The contractor must use other differentiation characteristics in the market, and not just price, to prove his suitability for performing the works. These include, above all, offering the client total services tailored to his specific needs as a basis for the construction works, and rendering these same services quickly and with a high level of quality. Sufficient run-up time for integrated, interactive works and production planning is crucial to allow the contractor enough time to plan the working drawings and the construction production processes in detail and accurately. Potential areas of planning optimization are to be found in the integration of all requisite works into a production planning process that takes all the technical, schedule and commercial aspects into consideration.

2.3 Information flow

One of the major problems currently facing project delivery is securing a coordinated, reliable and ongoing flow of information. The coordination work involved is considerable, given the fragmented approach to delivering projects caused by numerous independent parties involved in the project who all use different computer and information systems. One means of improving construction processes, both in the planning and delivery phases, is to use a consistent database which all the parties involved in the project can access to reduce interfaces (Figure 4).

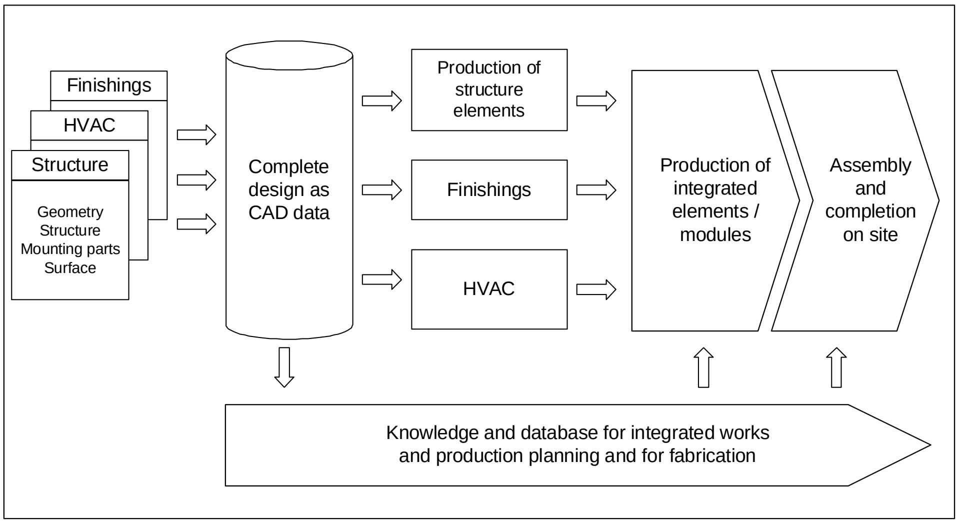

Figure 4: Structure of the planning and construction phases

These newly structured information processes require 3-D-CAD systems with linked data, and the creation of an intrasectoral standard for exchanging information. The currently common exchange of graphics does not meet these requirements at all. On the contrary, what is needed is communication among the various parties involved in the different project process phases, based on object-oriented information.

2.4 Systematic development

Aligning the planning processes to the production needs is a further step towards offering an integrated service from one source. This does not, however, mean that the production should dominate the design of a building. On the contrary, the so-called freedom of design should not necessarily be restricted, especially not in terms of architectural design. However, an analysis of the design alternatives quickly reveals that this freedom primarily exists in varying components, shapes and dimensions of the elements and modules to be produced for the building, and in choosing the fundamental layout and type of building. The technical details and schemes, such as wall or ceiling construction based on pre-defined dimensions, or sound and heat insulation requirements, as well as technical installations, offer broad scope for standardizing components.

2.5 Prefabrication, standardization, serial production

This standardization is also the basis for industrial production processes, which require a certain number of identical parts and / or elements and modules to be economically efficient. But identical elements or modules do not need to be of identical dimensions, they need to be identical in terms of the materials, the build-up of the construction from various materials, or the static impact. The material for serial production of elements or modules that is used recurringly in the same way is either kept available in storage or produced just-in-time; this can contribute to a considerable reduction in construction time since only those elements or modules that need to be manufactured individually have to be built once the contract has been awarded. To limit and standardize the material reduces storage and the bound capital.

2.6 Construction services as a product

If this approach were to be rigorously adhered to, a building could ultimately be compiled from a basic design and a choice of the various components and finishing elements. Various types or series could be compiled and then individualized by altering the parameters, as is standard practice in the automobile industry. This would result in a transition from individual structures, unique buildings that are newly developed each time, to an industrially planned and designed product. This is one of the approaches to genuinely industrializing construction, i.e. not always re-inventing each building, but the industrialized development of a product from an existing, largely standardized portfolio of components, whereby the product can be given an individual design by changing certain parameters in line with customers' preferences.

2.7 The shift from price to performance competition

The current situation in the construction industry does not allow cost benefits to be generated merely by improving methods. Each and every competitive advantage is equalled out by the competition within the shortest period of time, either by imitating the methods or by using subcontractors and, again, applying price pressure to them. The beneficiaries of this situation are the clients who only need to avoid awarding contracts under time pressure to allow them to take advantage of this cost spiral caused by the suppliers undercutting each other's bids. The consequence for the contractor is that he must avoid a comparability of his bid merely in terms of pricing and costs. Then, and only then, can his bid be assessed independently of a purely cost aspect, and in terms of its aggregate attributes and alignment to the client's requirements. In order to achieve this, the contractor may not just respond passively to tenders by submitting prices, but must sell a solution to a problem, in the widest sense, rather than just offering to perform works.

2.8 Incorporating marketing aspects

As a consequence of this approach to organizing a construction project, the opportunity arises of shifting the acquisition of contracts away from reacting to technical specifications towards active marketing and sales of customer-oriented buildings. These activities, unaccustomed for construction companies, allow them to differentiate themselves from the competitors in terms of actual performance, the range of products and services, and quality attributes [13].

A systematically developed variable building product which meets individual customer requirements with the right marketing mix can offer clients considerable benefits, since the composition of the same is known and understandable, and clients receive a precisely defined level of quality, which is not the case with today's traditional, fragmented, individually rendered services where the building with all its standard details is re-invented. In residential building construction, especially, design plays an important role. As long as a supplier is able to create a typical design with a high level of recognition, certain standardized quality attributes will be permanently and unconsciously linked to precisely this design.

3. Expanding the portfolio of products and services to become a system provider

3.1 Plan, finance, build, operate

The industrialization requires expansion of the design scope but also of the scope of responsibility of the "product" (the building) in one hand. Industrialization offers opportunities to tie in other activities that extend far beyond the actual construction. Initially it was turnkey construction and general services contracting that led to an expansion of the portfolio of products and services offered; these were followed by project development including financing and marketing services. Nowadays an integrated solution that meets the specific needs of a client is required in many areas, which can include operation and all manner of life cycle services. Irrespective of whether the building is destined for the client's own use, as a production facility or an investment, the construction industry faces the opportunity and the challenge of meeting all these needs and, in doing so, gaining access to client groups that were previously inaccessible [7].

As such, the provision of processing works is being replaced by a broad portfolio of products and services, whereby each of the areas of planning, construction, financing and operation – either on their own or combined – can open up new potential markets.

3.2 System competency, system providers

The need to develop such competency arises for anyone wanting to engage in industrial construction [7]. Companies need to be more and more flexible and able to offer integrated products and services along the value chain if clients so wish.

Industrialized system providers with specific products, services and customer segments interpreting system business as an integrated approach that affords equal importance to all the stages and components of this service, ranging from planning to construction to services, such as financing and operation, will open a window for new customer segments and for innovation. A purely construction management approach in industrialization is the wrong route to take, particularly for large corporations, because the integrated synergies and continuous improvements can not really be controlled. However, industrialization requires the integration of different key components of the value chain. The system provider needs to have the key competence in-house, but needs not necessarily to provide all performance and services by his own. The modern architecture of system providers in the industry concentrates on core competencies and a set-up of cooperation partners in a network. The future of industrialized system providers in the construction industry requires a paradigm change from stand-alone service providers with interchangeable subcontractors selected each time only on price criteria to strategic alliances with key designers, producers, and on- and off-site trades for the product and service offered [8].

The successful establishment of system competency depends on maintaining core business in-house, whilst buying in all the other expertise and components.

4. Outlook

4.1 Continuous development of construction methods

Experience from other industries has shown that the development of automated processes and robot technology, in particular, cannot be stopped once initially triggered. This surge in development requires the implementation of the requisite workflow, logistics, cost and/or quality advantages compared with conventional production and, in terms of equipment, units that can be deployed as independently as possible, and which are easy to operate and program. In the long term, the generally recognizable trend towards miniaturization in machine technology, i.e. developing smaller, lighter and simplified equipment with the same performance characteristics, but with ever more complex steering and control mechanisms, will, moreover, result in far more efficient solutions in process technology. Particular focus must be given to interoperability of different construction methods and equipments which, in general, operate in sequential but parallel workflow. Not the optimized single equipment or construction and finishing method leads to an industrialized, efficient, cost-optimal solution - to the contrary: the workflow, construction and finishing methods as well as the equipment must, in off-site and, in particular, in specific on-site construction operations, fit well together to reach an undisturbed high value creating over all processes.

4.2 Continuous development of information technology

As already outlined, the information flow will be the central element that will be used to control and link all the planning and construction areas affected by industrialization. Starting with high-performance data transfer concepts, and the integration of all parties involved in the project using EDM and internet solutions right up to the simulation of construction processes to provide prior information on efficiency, possible conflicts in the sequence of work, timeframes and costs, information technology will form the central nerve system of any industrialization.

In terms of industrial fabrication, the use of these methods and technologies requires a certain level of standardization and logistic planning to allow either the serial production and storage of frequently needed material, elements and components or the just-in-time manufacture of the same.

This offers considerable potential to reduce the construction time since only the really individual components for a specific building need to be manufactured once the contract has been awarded, whilst standard elements can be used to a major degree.

4.3 New contract and cooperation models

As a construction company's product increasingly shifts from providing processing capacities to an integrated system concept designed in line with client needs, the conventional contract models also reach their limits. New forms of cooperation are needed that are also demonstrated by new contract and compensation models. Switzerland has taken first steps in this direction with its "Smart building" [11] concept, a contract model that integrates the companies performing the works during the project definition phase already, and results in the structure being completed by work groups, where several trades are combined and offered to the property developer and performed as a "service package" by a group of companies, with the contractors who are involved being responsible for coordination within this package (Figure 5).

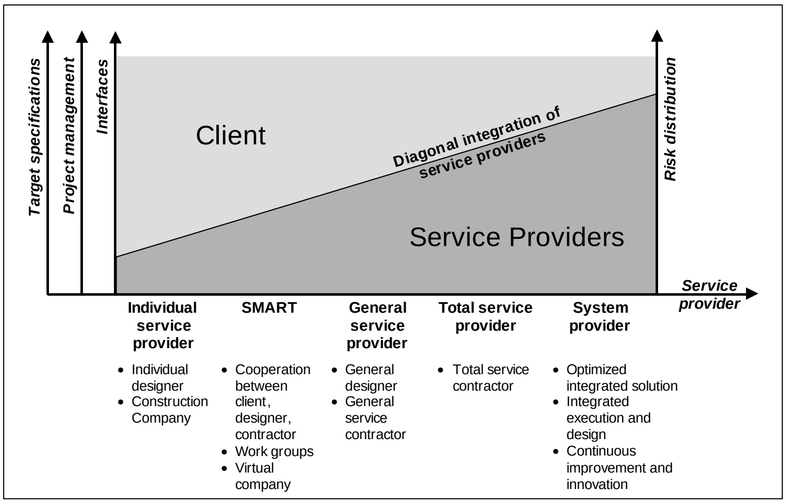

Figure 5: Project delivery models

In Europe, the growing practice of using GMP (guaranteed maximum price) with value engineering in total provision contracts (CM) [1], a contract model derived from American contract law, is a means of responding to the changed cooperation structures. With this form of contract, the client, planners and operators cooperate during the planning and execution phases openly and with the same mutual target to develop an optimized service within a fixed cost framework. This type of contracts could support the industrialization in construction industry to transfer early responsibility for the project to the contractor to allow the integration of building design in the production planning.

5. CONCLUSION

A construction company's orientation to client requirements that can extend far beyond the pure construction works forms the basis for developing industrialized system services and system competency [6]. Considerable earnings potential for construction companies can be found, especially, in providing supplementary services, since this area cannot be captured using standardized detailed specifications, but rather the contractor can use his creativity to set himself apart from the competition in terms of industrialized performance, by developing cooperative, innovative services comprising planning, construction, financing and operation, which are tailored to the individual requirements of each client.

The SysBau system services model developed by the Institute for Construction Engineering and Management at SFIT Zurich clearly illustrates this approach, thus forming a basis for integrated services within the framework of industrialized construction.

The systematic industrialization of manufacturing processes has already been implemented in all of those sectors of industry where top-quality, complex products are manufactured for a relatively clearly defined circle of customers, such as the automotive, airline or plant engineering sectors. Customers are offered all-in-one products, which demonstrate manufacturer-specific quality attributes, use cutting-edge technologies, are manufactured using state of the art fabrication methods and technologies, and, moreover, also include financing and other services incorporated in a cooperative supply chain.

The construction industry is also in the process of adopting this approach to industrialization. The future success of a company will depend primarily on its ability to identify the relevant potential areas of success and to take advantage of them, without fear of accepting new developments.

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Flexible Industrialization in Construction By Humanoid Construction Robots?

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Abstract

Robots were originally introduced in the production of industrialized building components and modular housing. Later mobile robots were developed for special on-site construction tasks. Automated construction sites use robotics for logistics and assembly. Recently humanoid robots have been developed and tested.

Keywords: Robotics , industrialization, prefabrication, customized production, construction

1. Overview

In the 1970s, many companies producing building materials on an industrial basis were founded by companies not otherwise engaged in construction. Ideas from automobile manufacturing, ship building and the chemicals industry were adopted by the construction industry. The 1980s saw the introduction of robots on building sites where they carried out specialized tasks such as spraying, smoothing concrete, distributing materials, fitting equipment to ceilings, assembling form-work, installing facades, painting and many more. In the 1990s, integrated systems for high-rise building were developed. These automated construction sites used robots for logistics and assembly. For around six years, humanoid robots have also been used for various applications on site, such as fitting interior walls, helping to carry slabs and driving forklift trucks and diggers.

2. Industrialized Prefabrication: Robot use in stationary building production

The Toyota Motor Corporation is known for its automobiles. However, it also has a factory for prefabricated houses in which it has successfully transferred manufacturing technology from the automobile sector to the construction industry. Toyota Homes produces from 4.5 to 7 houses per person per year. A Toyota house is assembled from room cells in up to 12 different sizes in four to six hours. In the factory, a room cell is prefabricated every 2.5 minutes.

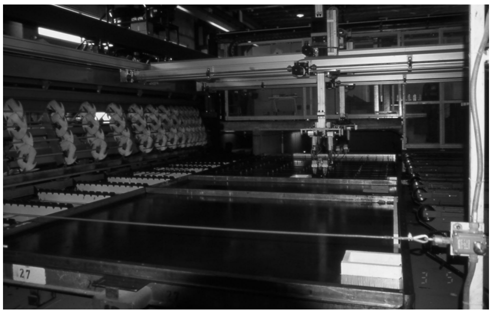

Figure 1: Flexible CADCAM gantry type production unit for PC floor, wall and roof elements

Customers can put together their dream home from over 350,000 single parts. Computer-aided design and computer-aided manufacturing systems produce approximately 2,000 components from around 25,000 parts, which in turn make up approximately 300 functional modules. Despite such a huge variety of parts, no manufacturing defects arise.

Figure 2 shows a robot for customized masonry prefabrication

So that customers do not become confused by the huge amount of choice, they can use virtual reality to walk through their dream home and can change anything they do not like before they sign the contract. If they approve of the simulation of the house and agree with the price and the financing terms, the CAD/CAM system starts the manufacture of the components and room cells, from which hardly any waste results. The quality of the robot-aided manufacture at Sekisui and Toyota Homes is so high that the company guarantees its prefabricated houses for between ten and twenty years. They are high-value products, manufactured with industrial expertise. The Sekisui suppliers work on a four-day cycle, planning one day for processing the order and preparation, two days for manufacture and one day for shipping.

Figure 3 shows a robot for customized wooden panel production

In a country where wages are high, a high-investment business will only thrive if it can operate continuously with help from the marketing department. Like the Toyota Motor Corporation, Toyota Homes is managed on a marketing-oriented basis. Marketing controls the robotized production systems at Toyota Home in the same way as the Andon and Kanban systems at Toyota Motors. Customer orientation comes first, which builds up a good reputation with satisfied customers. This service is rewarded with increasing sales of prefabricated houses in Japan where the building industry is otherwise in decline.

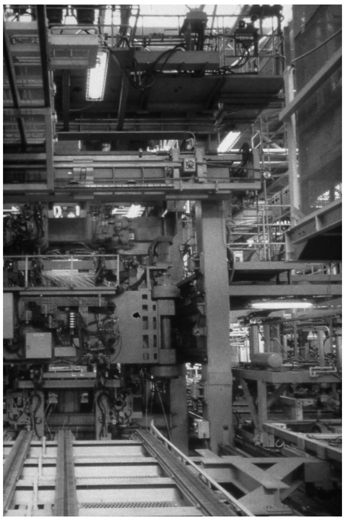

Figure 4 shows a robot for customized steel frame based box unit production

3. Mobile construction robots

Big Japanese construction companies have been researching and developing robotized construction processes since the beginning of the 1980s. Initially, individual robots and remote-controlled manipulators were developed for specific processes on building sites. This included robots for delivering concrete, handling concrete, applying fireproofing to steel constructions, handling and positioning large components and, as a final example, facade robots for plastering and painting. Over 400 different prototypes were developed and tested on building sites.

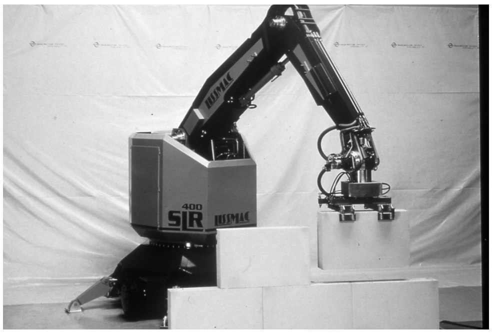

Figure 5 shows a mobile brick laying robot

They all had in common that they were intended for use on specifically defined tasks under building site conditions and were not supposed to have an adverse affect on the work carried out by the construction workers. It became clear that only a few robots were economic to use under these conditions. The restrictions on the workers, the safety regulations and the unforeseeable and unplannable events that affect building sites strictly limited the use of individual robots in parallel with normal work. There are only a few currently in economical use or offered for sale on the market. Examples are the concrete smoothing robots from Kajima and Tokimec. This development revealed that it is difficult and, in particular, not economic to transfer production conditions from the factory floor to the building site. This might seem to be a mundane and predictable result, but it must be acknowledged that these developments were only seen as a first step on the way to automating construction processes and that economy was not the primary objective.

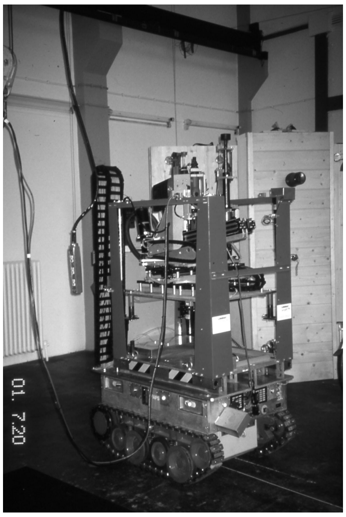

Figure 6 shows an interior finishing robot

There are two other crucial results of significance to the future of the Japanese construction industry. The first is the knowledge and skills acquired in the area of automation and robotics, and the preparation of workers for innovation in the construction industry. The second is the groundwork for the real objective - to automate the final assembly of a building on a building site under factory-like conditions and in bringing to bear the laws familiar from serial production.

4. Automated high-rise construction sites

The first prototypes for automated high-rise construction sites were put into operation in 1990 and 1991 after five years in development and a financial outlay of almost 16 million euros. Since then, 20 automated high-rise sites have been operated by different companies.

An automated high-rise construction site is understood as the semi- and fully automated storage, transport and assembly equipment and/or robots used to erect a building almost completely automatically. It is the attempt to improve the sequencing of construction processes and construction site management by using real-time computerized control systems. This includes an unbroken flow of information from planning and designing the building through programming the robots with this data to using computers to control and monitor building operations on site.

Figure 7 shows an automated construction site in September 2003

After the foundations have been laid, the production equipment, on which the steel construction has been installed with assembly and transport robots is covered completely with a roof of plastic film. Depending on the system, this takes from three to six weeks. Then the robots go into action. Two steel and ten concrete plants supply parts in ten-minute cycles on a just-in-time basis. This approach to supplying is not necessarily part of the system, but is due more to the lack of space around building sites in large Japanese cities. The prefabricated parts are checked and then placed in specific depots at the foot of the building or in the building itself to be available to the robots. This is where the automated construction process actually starts. Up to 22 robots equipped with automatic crane winches deliver the pillars, supports, floor, ceiling, wall and other elements to the floor of the steel skeleton under construction. They are also, in the main, positioned and fixed into place automatically. The steel pillars and supports are joined together by welding robots after they have been positioned. The position and quality of the welding seam are monitored with lasers.

Once a story has been finished, the whole support structure which rests on four columns is pushed upwards by 12 hydraulic presses to the next story. Three 132 t presses in each pillar are required to achieve this in 1.5 hours. Fully extended, the support structure is 25 meters high; retracted it measures 4.5 meters. Once everything has been moved up, work starts on the next story.

By fitting out the topmost story of the high-rise as the roof at the beginning of the building process, the site is closed off in all directions, considerably reducing the effect of the weather and any damage it might cause.

Figure 8 shows the same site in March 2004

This system reduces labor requirements by around 30%. Future projects are expected to achieve a labor saving of around 50%.

The building consists of a remarkably high proportion of prefabricated parts. Once the foundations have been laid, the remaining construction procedure can be described as a matter of configuring transport and geometry. All the elements are prefabricated; only some of the fitting, joint insulation and other minor works need to be carried out by hand. Problems with the construction arise less from the timing of deliveries of materials or from the choice of processes and/or machines but more from the need for accurate planning, from programming the robots or from the just-in-time supply of parts.

5.Servicing robot systems

In Japan the first facade and roof robots were developed and put into operation at the beginning of the 1980s. It should be noted that these devices were almost all without exception developed by the technical departments of large building companies or by their construction machinery suppliers and not by service providers or cleaning equipment manufacturers. This was due to the closely defined area of application of the equipment which, as a rule, was used only on one large building erected by the company in question. There are many varied applications. First of all there were heavy, rail-guided robots such as the exterior wall-painting robot from TAISEI, which was developed to apply paint to the 100,000 m^2 facade on the 220 meter high Shinjuku Center Building in Tokyo.

Picture 9 shows a watchdog service robot

6. Latest development: Humanoid construction robots

Humanoid robots for construction work have been developed and tested for six years. The robots can carry a joinery bench together with a construction worker, fit an interior wall, and drive forklifts or diggers. They can move over gradients of around five degrees and compensate for up to two centimeters on uneven surfaces. They can right themselves when they fall over.

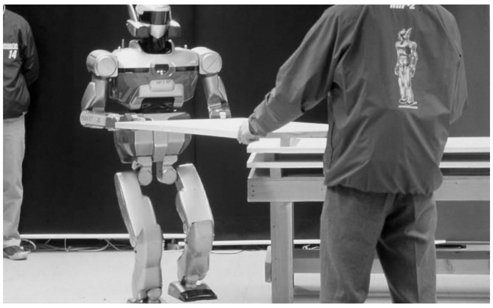

Figure 10 shows a humnoid robot carrying a construction board with his human colleague

When carrying a component with a human, they use an adaptive and flexible arm system. An image processing system with a mobile portable control system has been developed to allow location detection. When it moves over uneven surfaces, a force sensor in the sole of the foot and a balance sensor in the body register the difference and the gradient allowing the robotic control system to adapt the sole of the foot to the surface.

Figure 11 shows a humanoid robot riding an excavator

7. Conclusions

The research, development and application of industrialization to construction during the last 3 decades shows that by using robotic technologies in prefabrication, on site construction and services, we will be able to achieve customized building products at affordable construction costs and constant quality.

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Systematic Optimization of the Construction Process by Implementation of PRSM (Process-oriented Risk-based Selection Method for innovative construction techniques)

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Abstract

Today's fierce price competition demands that contractors find the optimal solution in the construction process, as inefficiency can no longer be accepted. A reconsideration of the present approaches to decision-making shows the need for an integrated decision-making tool. PRSM is a knowledge-based decision-making model that uses pre-structured processes to allow the interferences that occur between parallel and/or sequential elementary processes when constructing buildings and cyclically repetitive tasks to be taken into account when choosing systems (formwork, equipment, concepts, etc.). The application of this method makes it possible to clearly demonstrate the impacts of system decisions on the overall system. This tool will lead to high performance on site as well as to a reduction of non-value added process activities. The project specific and process oriented choice of construction techniques is a core competency of construction companies and does have a very important impact on the efficiency and effectiveness of the work and the costs involved. Since systematic decision-making tools are missing and the time for work preparation is short, construction techniques are mainly selected on the basis of experience and subjective calculation of the project even for major complex projects. Single sequential construction processes are optimized separately regardless of their interactions and their dependency.

Keywords: selection method, process-oriented, risk-based, PRSM

1. Introduction

1.1 Status quo

An analysis of various buildings with a similar layout and number of floors reveals that the construction methods chosen to build the structure varied significantly in parts. The fact remains, however, that the completion of all projects was technically faultless. As such, the decision to opt for this or that construction method cannot have been based on objective principles, but rather on subjective criteria, such as predisposition or preference on the part of the project manager.

The choice of project-specific and process-oriented system solutions represents one of the core competencies of a construction company and can influence the efficiency and productivity of the company to a major degree. An analysis of the current profit margins of German construction companies - which barely exceed 1% [1] and are reflected at the same levels by most other Central European countries - reveals that all means of optimization need to be exploited. Moreover, analysis reveals that construction contracts are generally awarded on the basis of pure price competition [2], which is why a systematized and, above all, risk-based decision-making process is of such enormous significance, particularly in the case of such contracts.

Attempts made in the past to support and optimize the planning and construction processes using computer aids nearly always produced aids for monitoring schedules and controlling costs [3][4]. As such, however, the construction process is only receiving support at a relatively late point in time, by which time the strategically important and, as such, cost-relevant decisions in terms of methods and procedures have already been made. The aim of this research project is, therefore, to develop a decision-making model that allows system decisions based on objective fundamental data to be made early on, whilst the planning and work preparation phases are still ongoing. The construction process is being analyzed as a whole, including the various interactions between the partial processes, with clearly trackable performance data being obtained that can subsequently be used for cost comparison purposes.

1.2 Approach

The choice of the optimal project-specific system solutions represents a complex task since all the interactions between the various partial processes that can impact performance need to be taken into consideration. The aim of this research project is to provide pre-structured process models that enable the decision-maker to base his choice of system on knowledge of the individual impacts on the entire system, whereby focus is not on selecting the optimal system for a work area taken on its own, but on choosing the systems in such a way as to ensure an overall optimum for the project.

Up until now, decision-makers in the bidding and work preparation departments processed each and every one of these points manually. It would be unrealistic to assume that, in doing so, every single interaction, constraint and economic impact of the possible individual combinations of systems could be taken into account. As such, the process model developed at the Institute for Construction Engineering and Management at SFIT Zurich aims to offer such decision-makers an effective and utilizable decision-making aid.

The possible uses of PRSM cover all structures demonstrating a recurrence of similar work cycles in a horizontal or vertical direction, such as tunnels, roads or high-rise buildings.

The development of PRSM is divided fundamentally into two principal tasks. The one focuses on modeling the structures, with the aim being to collate the geometric constraints into a form (building model) that can be processed systematically. The second challenge comprises a definition of the interactions and interdependencies among and between the individual partial processes. The only means of ensuring with a high degree of probability that the partial processes and their interferences have been correctly defined and, in consequence, can be correctly incorporated into the process model, is by involving experienced practical experts.

2. Development of PRSM

2.1 Procedure

A survey among respected construction companies in Switzerland and its German-speaking neighbors supported the assumption that there were fundamental weaknesses inherent in the decision-making process used to select systems. The interviewed members of management and employees in the calculation and work preparation departments confirmed this assumption and indicated the following principal failings of the system selection process:

- Unsystematic selection process
- Selection is based on limited knowledge of process interactions
- Decisions are made on the basis of limited information know-how
- Decisions are made purely deterministically, without taking any disruptive factors into consideration

The subsequent in-depth study of literature that was aimed at discovering references to automated decision-making models only revealed a very few usable results. Fundamentally methodical approaches were identified in works by Girmscheid [5], Mawdesley [6] and Motzco [7]. These works only indicate fundamental principles, however, without claiming to provide an integrated analysis. The required renunciation of the common practice to date of analyzing individual partial processes more or less in isolation from each other, due to the lack of appropriate tools, in favor of a total interconnection of all processes and, in consequence, the overall analysis of the technical and commercial impacts of individual system decisions necessitates the development of a knowledge-based decision-making model, PRSM.

So far, the development of this model has reached a stage where it can simulate the influence exerted by system decisions during the construction process of a high-rise building. A risk analysis is needed in order to be able to incorporate the disruptive factors that are constantly occurring during practical construction works into the model; this will be incorporated into the already existing model in the next phase of development.

2.2 Scientific methodology

Constructivism is the primary research method being used to develop this decision-making model since it designs systems based on an intended input-output effect.

The theory-based structure of the model is derived from a constructive approach based, firstly, on scientific mathematical methods, such as workload, cycle and cost calculation, and, secondly, on the simulation of fuzzy variables with regard to the calculation process.

Triangulation is being used to ensure validity and reliability using the theory-based scientific structure, on the one hand, and the realizability test being performed on construction projects of the companies involved in the research project, on the other hand.

2.3 Method of resolution

2.3.1 Modeling of building structures

The ability to present a complex building structure as a model requires high levels of experience and knowledge of the structure. If this knowledge is lacking, then material details might be neglected or incorrectly reproduced in order to simplify the model, resulting in the ensuing interactions not being able to be incorporated into the subsequent workflow. The modeling process therefore needs to be conducted carefully and by specialists.

Basically, modeling aims to transform building structures, where the designer has defined the dimensions, into a geometric model in order to allow the standardized further processing – i.e. using a program – of the same. The degree of detail and other demands on the model depend to a major extent on the type of building structure and method of further processing. A model of the components as slabs or rods with their relevant internal forces might suffice for a static analysis, whereas more complex models would be needed to simulate the manufacturing processes.

After examining various alternatives for an approach to modeling a multi-story building with a reinforced concrete frame construction, the use of modules proved to be the most effective, with standardized partial modules of individual floors containing ceiling sections, columns and even the core in places, being used to model an entire building structure. The modules in question are typical, recurring layout shapes that can be combined to map virtually any building structure with virtually any layout design.

Examples of a core module and edge module are illustrated in Figure 1 and Figure 2, respectively.

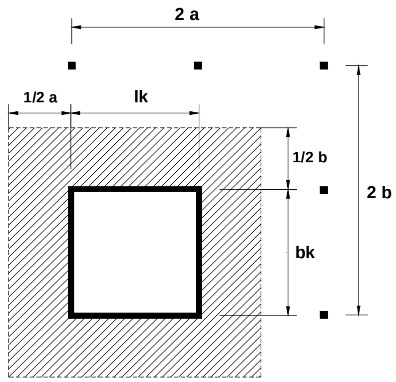

Figure 1: Core module

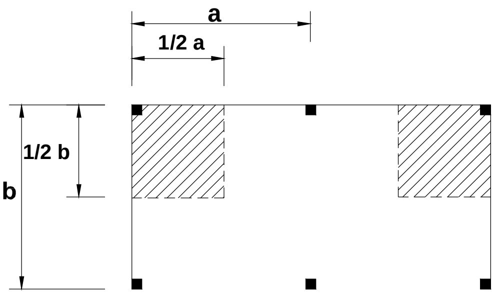

Figure 2: Edge module

2.3.2 Choice of system

Using a multi-story building with a reinforced concrete frame construction as an example, we will demonstrate that the strategically critical choice of system primarily relates to the individual formwork systems for the principal construction elements of ceiling, core (walls), columns, girders and staircases. To enable further processing, the individual formwork systems are listed with all their relevant advantages and disadvantages, and the problems that are already identifiable where other formwork systems interconnect are indicated.

A matrix was drawn up to define all the theoretically possible system combinations and subsequently subjected to a plausibility test, together with practical experts. The approach was as follows: Following the selection of random individual systems for ceiling, columns and core, any potential problems in execution or even reasons for exclusion were revealed. On the basis of this matrix the technically possible and practically relevant system combinations thus identified were linked. This combination scheme as outlined in Figure 3 provides the framework for all ensuing considerations with regard to possible areas of conflict at system crossover points.

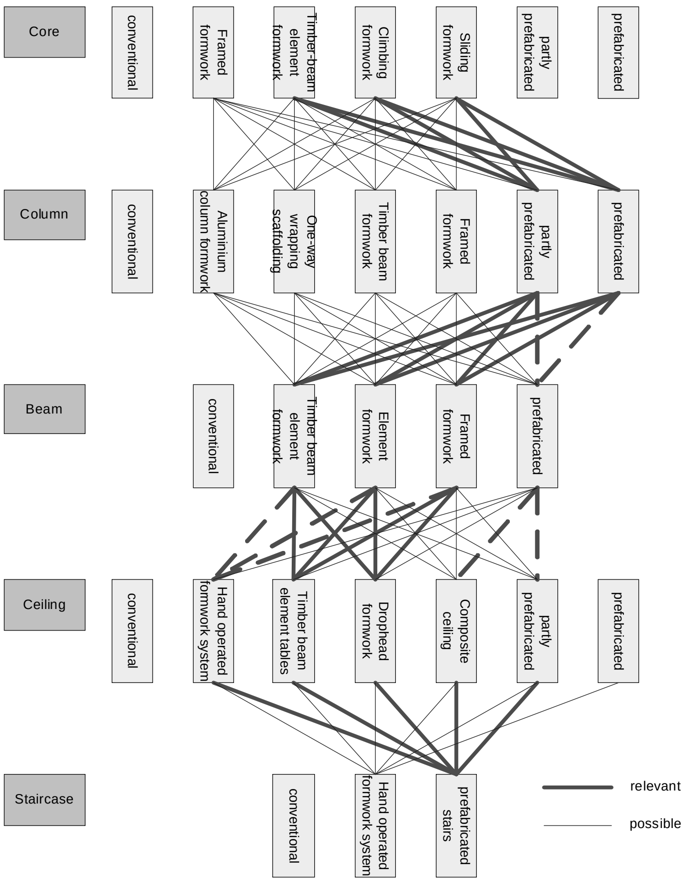

Figure 3:System combinations

The following process steps need to be defined in order to analyze the cost efficiency with an end to simulating the total process flow.

2.3.3 Analysis of the elementary processes

In order to enable the comparability and illustration of the interdependencies respectively the interactions among the individual construction elements, all the construction processes within the individual modules were split into their so-called elementary processes. This breakdown is performed within the modules for each and every possible combination of construction elements and systems. Subsequently the relevant demands on work area or building site infrastructure (crane, hoist, concrete pump, etc.) are defined for each elementary process.

The elementary processes defined using this approach are evaluated in terms of time and costs, with the cost bandwidths contained in this evaluation and associated risks being assessed using the qualitative empirical method developed by Mayring [13] and Yin [14]. The results were processed using the interpretivistic research approach (developed by Weber [8] and Girmscheid [9]), the risk model is being developed using the constructivist research approach (developed by Piaget [10], von Glasersfeld [11] and Girmscheid [9]).

2.3.4 Analysis of interactions

An analysis of the interactions depends to a large degree on the planned construction workflow of the high-rise building being examined, with the fundamental issue being whether the core is being constructed precursory or the structure is being built floor by floor. Nowadays, staircases are generally delivered to the building site as pre-fabricated components – and are positioned at some random point in time, the only condition being that the surrounding walls have already been built and the stairwells are accessible.

In addition to these possible variations for core and stairs, the practically relevant system combinations illustrated in Figure 3 can be further subdivided relative to their construction sequence, where – depending on the structure – it might be beneficial to manufacture the components separately and directly after each other, or, at times, to produce them together.

The interdependencies are evaluated in line with four criteria:

- constructive interaction:
  formwork and construction link between the construction elements
- geometric interaction:
  reciprocal obstruction of formwork, reciprocal obstruction of columns and supports for the formwork systems, saving concrete platforms by simultaneously manufacturing individual construction elements, available space (core, edge, corner)
- temporal interaction:
  integratability into the cycle, saving time by performing simultaneous formwork works / concreting individual construction elements, losing time by separately manufacturing individual construction elements
- logistical interaction:
  crane deployment, workforce separation, formwork “idle time”, material deployment

The interactions are evaluated on the basis of the basic construction sequence Walls → Columns → Beams → Ceilings → Staircases, i.e. the columns are interacting with the walls, the beams with the columns and walls, etc. The qualitative and quantitative evaluation of the individual interactions must be performed together in close collaboration with specialists with practical expertise and must later be tried and tested in practice on several construction projects, and adapted where necessary.

2.3.5 Analysis of the cost-efficiency of the system combinations

The time-relevant and, as such, cost-relevant impacts of these interdependencies are analyzed within the framework of a cost-efficiency analysis of the individual system combinations, which is divided into three parts:

- Performance calculation
- Cost calculation
- Risk analysis (uncertainties surrounding deadlines and costs)

2.3.5.1 Performance calculation

Determining the performance of the overall process is based on the performances calculated separately for each module or even for each construction element within the individual modules. The partial work processes are calculated using the method developed by Girmscheid [12]. To incorporate the interactions and the ensuing time differences (in both a positive and negative sense) the surcharge values obtained from building site practice are added to the workload figures. The total time is the aggregate of the partial times of each individual module.

2.3.5.2 Cost calculation

In the model developed here, the costs are calculated automatically based on the performance calculation, with the program accessing databases containing the relevant basic data for the detailed calculation of the wage, material and equipment costs. These figures can be replaced or supplemented by each and every construction company incorporating its own calculation methods. The method of calculation is largely aligned to the recommendations made by Girmscheid [12] and complies with the guidelines issued by the Swiss Association of Construction Entrepreneurs (Schweizer Baumeisterverband, SBV).

2.3.5.3 Risk analysis

The cost bandwidths ascertained back in 2.3.3. and the relevant density allocations of the individual elementary processes are incorporated into the program in the next phase of development. Inputting the essential parameters in the form of expected values together with their upper and lower limits would be conceivable.

The individual probability distributions cannot simply be aggregated to reach the probability distribution of the total costs, but rather they need to be linked in line with the law of probability as the value calculated would otherwise be much higher than the actual value.

If there were only two probabilities, this could still be achieved purely analytically, but with multiple density allocation functions for the cost groups, such as is the case here, a simulation model has to be used instead of an analytical model.

Instead of individual figures, this process produces bandwidths for the calculated costs combined with the probability distribution for the aggregate anticipated costs, thus providing the decision-makers in the calculation and work preparation departments with a sensible decision-making aid on which they can base a thorough and justified choice of a certain system combination. Figure 4 provides an overview of the PRSM approach.

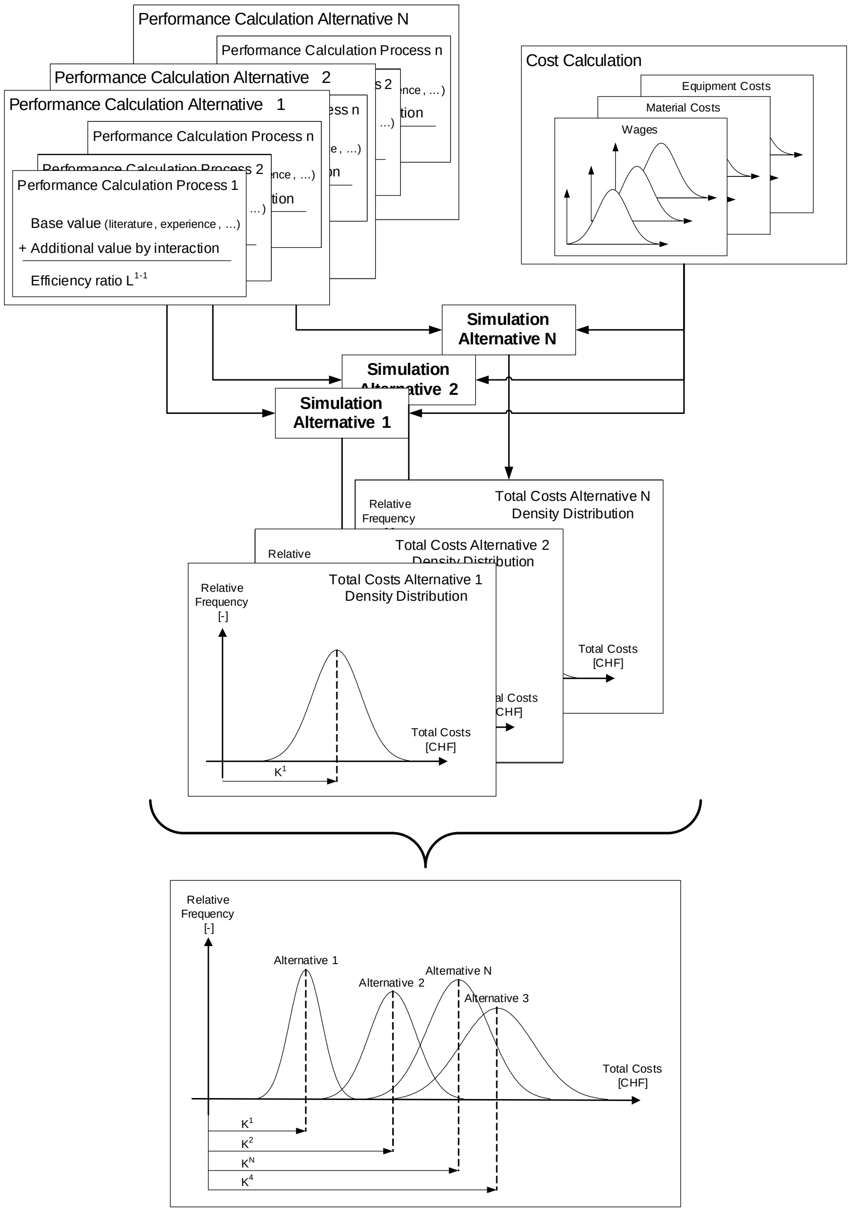

Figure 4: Fundamental methodology of PRSM

2.4 Results

The following findings emerge from this research project:

- List of all the interactions arising from the system combinations, qualitative and quantitative
- Information on the impacts of system decisions on the construction process, available at short notice
  The impacts of individual system combinations on the overall system in terms of construction time, work cycles and the associated overall performance can be systematically analyzed using PRSM. The model enables the illustration of the cycles for constructing both an individual standard floor and the entire building.
- Information on the impacts of system decisions on the costs of the building structure, available at short notice
  The choice of a system combination has direct impacts on the wage, material and equipment costs. The automated cost calculation makes it possible to evaluate the costs of various system combinations at an early stage and, as such, to select a cost-optimized and cost-stable system.
- Information on the impacts of system decisions on the stability of the construction timeframe, available at short notice
  The risk analysis makes it possible to evaluate various execution alternatives / different system combinations using the relevant bandwidth for the duration of construction works and the associated density allocation.
- Information on the impacts of system decisions on the stability of the construction costs, available at short notice
  The risk analysis makes it possible to evaluate various execution alternatives / different system combinations using the relevant bandwidth for the costs of executing the construction works and the associated density allocation.

3. Conclusion

3.1 Reasons for developing PRSM

When past reference was made to optimizing construction processes, efforts generally focused on optimizing individual partial processes, virtually in isolation of each other. The interactions and interdependencies between and among the individual partial processes were ignored for the most part. When analyzing the overall process, however, it is, indeed, possible that a suboptimal process sequence of a partial process (e.g. within a construction element) turns out to be an optimal sequence in the overall process (e.g. module). For this reason, an optimization of the overall process is not equivalent to the aggregate of all optimal partial processes.

As literary research further demonstrates, there are approaches that are heading in the right direction, but to date no integrated concept that encompasses the entire complex process of erecting a building structure has been identified.

The commercial potential offered by PRSM can be clearly demonstrated by taking into consideration that the proportion of unproductive hours due primarily to obstructions caused by non-compatible system decisions and insufficient coordination of the work processes is estimated to be approximately 30% on average. Using PRSM would allow a marked reduction in this percentage and, as such, an increase in productivity.

Moreover, new developments can be easily incorporated into the model to ensure that information know-how is available with the right information in the right place. All of the primary system selection failings indicated in 2.1 can be eliminated using PRSM.

3.2 Outlook

The principle of PSRM is not just limited to use on shells of multi-story buildings with reinforced concrete frame constructions. On the contrary, this is just an example to demonstrate the optimization potential offered by the deployment of systematized, process-oriented and risk-based decision-making models.

Other conceivable applications, for which the model would need to be adapted, include, primarily, building sites with cyclically recurring work steps, i.e. line construction sites, such as tunnel, road or bridge construction.

The tense economic situation within the construction industry makes it imperative to exploit all possible means of optimization, not just during the actual construction process. In order to make full use of this potential, we must refrain from studying individual partial processes virtually in isolation of each other and start focusing on the complete link-up of all processes and, as such, arrive at an integrated analysis of the technical and commercial impacts of individual system decisions. The process-oriented and risk-based model PRSM supports decision-makers and enables superior performance on the building site by reducing unproductive works.

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How Industrialisation Serves a Client Focused Industry and How Clients Appreciate the Approach

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Abstract

There is a tendency in the housing market to give future tenants more influence in the design of their houses. Designers and project developers experiment with a variety of new ways to involve the future tenants. Around the turn of the century the industry of building components and the big contracting companies understood that here was a chance to gain market share. They launched new products and new processes to better meet client's needs. New products were designed to deliver flexibility in use. New processes were developed to allow more client specific variation and client's choice in a later stage of the process. One recent Dutch project went to the extreme. Tenants of an apartment building under design were allowed to bring their personal architects to the project team and have even their part of the facades personalised. The reasons why this and some other client focused process were finally not a success, while other strategies for client focussed actions turned out to be good selling, were investigated. The new developments were monitored to asses the effectiveness and appreciation of the new strategies of the industry.

Keywords: Industrialisation, Mass Customisation, Open Building, Personal Housing.

1. Some recent developments in the market

1.1 Growing demand

For many years the housing market was a sellers market. In most western countries there was a shortage of houses. So new houses were easily sold or rented out. The quality of design and construction were not very decisive factors in the marketing of the product. The long lasting shortage had nothing to do with low production. On the contrary the production capacity grew over the years. The shortage was mainly caused by the fact that the average number of inhabitants per house decreased steadily. The most common family size came down to about 4 persons. Two parents and two children. But also the increasing number of divorces was a reason for the growing demand for houses. In Western Europe the average occupancy of a house is now down to 2.5 and there is a tendency to an even lower figure. Also the flow of refugees from all over the world, mainly to Europe and America, was a reason for a growing demand and consequently a structural under supply. The figures for the Netherlands demonstrate this development. Between 1998 and 2002 the population grew with 2,88%. In the same period the number of households grew by 4,28%. [2]

1.2 Decreasing supply

Recently it appeared that houses are not any longer that easily sold. The reason is not found in a decreased demand, or in an over production. Though the birth rate is stabilising and the number of immigrants in Western countries is falling back. These factors are not yet strong enough to cause an effect on the demand side. The reason for a stagnating market is found in rising prices and an economy in recession. The economies of most developed countries are in a recession that started in 2000. As a consequence many employees lost there jobs. The recession came together with a collapse of the stock exchanges. The Dutch stock exchange index was reduced to less than half its highest value. So retired people and businesses lost capital and purchasing power. This resulted in a significant decrease in the effective demand for housing. While the market lost purchasing power the construction industry could not lower its prices. On the contrary the prices of new built houses and offices continued to rise at a rate above inflation. Even a dramatically decreased production could not prevent an oversupply of houses and office space. The number of houses completed in The Netherlands decreased over the years 1998 till 2002 from 90.500 to 66.700 units. The prices of single family houses increased with 62%. [2]

1.3 Customer focus

In the late nineties the supply side of the market became aware of the fact that a high demand and an under supply had made selling of houses too easy. There was no driver to meet the requirements on the demand side of the market. This resulted in a misfit between supply and demand. Many clients were not satisfied with the quality of the products, nor were they satisfied with the attitude of the suppliers in case of complaints. Investigations into the market showed that tenants wanted more variety and more influence to personalise their homes. Real estate funds required more flexibility to meet future needs. And all owners wanted a better quality at completion. In particular they complained about the ever occurring remedial work to be performed after hand over. It was clear that a more customer focussed market approach was needed. The awareness of a need for more customer focus came before the collapse of the market. But decreased demand caused a sense of urgency. It forced the industry to introduce the new client focussed strategy immediately.

2. The supply-side response: industrialisation

2.1 Industrialisation

The supply-side of the housing market reacted to the new demand with a move to what is generally described as industrialisation. To understand this move a definition of industrialisation should be given first. Industrialisation is a word with a wide scope. The word is often used, but an exact definition is difficult to give. Industrialisation in Building is generally understood as the development towards a building process that is

- Better under control,
- Benefiting from the effect of repetitive processes,
- Benefiting from the effect of mass production,
- Benefiting from the support of mechanised and automated tools,
- Organised as a permanent process rather than incidental.

This list could be completed with more characteristics. It is just a rough sketch to get an idea of what we are speaking about. In construction we see two basically different approaches to industrialisation. Some parties concentrate their efforts on changing the processes on-site. Others expect more from moving the production to an off-site facility. Another distinction between approaches is between product industrialisation and process industrialisation. [6]

2.2 The strategies

Most parties in the construction industry understood that a new client is emerging. A client that was seeking for a more personal approach. Architects, developers, contractors and investment funds, they all had to reconsider there processes and products. They all had to ask themselves how to meet the changing requirements of the market. How to deal with a demand driven industry. Each party sought his own reply to the arising demand for a more client focussed production. The strategies can be divided in four categories.

1. <u>Mass customisation.</u> Developers and contractors were used to offer a standard product with little choice for variation. These parties choose mass customisation to better meet client's needs. They developed a more flexible process, allowing for more alternatives and for decision making later in the process. It can be categorised as on-site process industrialisation.

2. Prefabrication of components. Suppliers of components developed new products especially designed to enable tenants to change their homes later. This is categorised as off-site product industrialisation

3. Prefabrication of elements. The suppliers of catalogue homes and prefabricated units who always had build single houses to client's specification, had no reason for a strategic change. Their processes had always been very client focussed. This is off-site product and process industrialisation

4. Prefabrication of unit. Some manufacturers of voluminous units for temporary facilities but also an off-shore construction plant studied the possibility to radically change the industry by moving production of buildings completely to factories. Not just components or elements but full sections of buildings, installed and finished, ready for use. This concerns also off-site product and process industrialisation

2.3 Mass customisation

In the Dutch market almost every mayor construction company developed a new concept for housing. Commercially attractive names were given to the new products, such as "Wenswonen" (Desire Housing) by Heijmans Contractors, "Smart House" by BAM Contractors, "Persoonlijk Wonen" (Personal Housing) by Bouwfonds Development, "Multiple Choice Homes" by Koopmans Bouw, and many other beautiful brand names. All these concepts advertised that within certain limits clients were enabled to make a personal choice from a variety of alternatives. The alternatives included additional rooms, position on the plot, location of kitchens and bathrooms, façade materials etc.

Figure 1: Smart House, a product of mass customisation.

The most extreme step to better meet client's expectation was the 7 Heavens project in Rotterdam, The Netherlands. Here a project developer allowed prospective buyers to select their own architect and design their own apartments within the frame work of a steel load bearing system completed with staircases, lifts and riser ducts. Even the facades were to be design by the private architects. Some hurdles had to be taken. The building permit for a building without a design for the facades was in principle not possible. The city of Rotterdam supported the innovative process, made an exception and awarded a building permit. The Ministry of Economic Affairs was prepared to give a financial support. And also the project developer was prepared to invest extra budget in this innovative process. [3] [5]

Figure 3: the 7 Heaven project, facades according to clients design

One may say that in this approach the influence of the client has so much impact on the process that it can not be considered as real mass customization. The progress of construction is too much dependant on the process of decision making by the client. In real mass customization the manufacturer or contractor should keep full control over the planning.

2.4 Prefabrication of components

A strategy typical for the suppliers of the construction industry was the development of new components suitable for postponed decision making and for future modifications to houses. In particular suppliers of flooring systems came with new flexible systems. In the Dutch market prefab concrete has a long standing tradition. For floors there is a wide variety of systems available such as hollow core floor slabs, wide-slab floors and Bubble Deck floors. All these systems are designed for cabling and ducting cast into the floors. It forces designers to early decision making on the services and does not allow tenant to any modification later on. The manufacturers of these floors understood that a market for flexibility was arising, driven by client's demand. New products to meet these new requirements were developed. The hollow core floors are now available with a lower zone to put cabling in. Wide-slab floors are produced with a lower zone covering up to 50% of the slab. In stead of the old products with cast-in piping and cabling the new floor slabs provide now openable ducts where cabling and piping can be installed in a later stage of the building process. This services also may be replaced to meet future needs better. [10]

Also openable floor systems based on steel beams and removable toppings were introduced on the market. The A+ systems should be mentioned here as one of the most successful systems. It is based on steel beams, cast with the lower flange into a concrete slab. The beams are perforated to allow the passing of cables and ducts. The upper flange supports a removable flooring system. The space between upper and lower flange is accessible for tenant when they want to modify their services systems. [7]

2.5 Prefabrication of elements

Another market response were new developments of prefabricated homes. Factories for prefab houses existed already for decades. The market share did not rise above 2 percent of the Dutch housing market. A push came from the Dutch ministry of housing. The minister proclaimed a new policy aiming at a target production of 30% housing by private initiatives. The target may be far from realistic in a country where land for such private clients is scarce, but a substantial rise in the market share of prefabricated houses can certainly be achieved. Several small and medium sized contractors redesigned their business and joined the industry for catalogue homes and offices. They range from wood framed houses to prefab concrete systems. Transportability over public roads is the main constraint to these systems. For that reason most suppliers of prefabricated houses produce systems based on the pillar-slab concept or the slabs-only concept where the frame is incorporated in the elements. [8]

For the 7 Heavens project it was proposed to make façade elements, with standardised connections, but client specific appearances. The initiators considered a concept with mass manufacturing of standardised façade elements, with a take-back service and a second hand market. For the time being the concept is not yet expected to be feasible.

2.6 Prefabrication of units

One step further in this development is the manufacturing of houses and offices based on voluminous units. In particular suppliers of site offices and temporary housing facilities have chosen this strategy. They developed houses consisting of a number of units. Each unit is approximately 3 meters wide and 3 meters high. These dimensions are just acceptable in normal traffic. On site a number of these units is build together to a complete house. The concept existed already in other countries. In particular Japan is known for this approach. In the Dutch market the phenomena is still rather unique but gaining market share. [9]

Some manufacturers produce floating prefab houses. Not an unsuccessful approach in a country with much water and scarcity of land for construction. The construction of a factory for the continuous production of floating houses was announced in early 2004, but production has not yet started. Still a small industry for floating houses is emerging. Unlike the traditional house boats these buildings look good. Quality is comparable to traditional housing.

Figure2: A factory made prefabricated house.

Another industrial strategy to meet client's needs better is found in the production of units for one specific use like bathrooms and kitchens. This strategy also uses prefabrication of units as its starting point. But these units are considerably smaller then the units mentioned before. Transportation is not a problem. Exterior appearance is not a problem either. These units are incorporated in a building and in many cases hidden behind partition walls. The prefabrication of sanitary units occurred already for some decades, but on a project bases. A more continuous production is expected when client focussed building really breaks through.

The ideal of producing also bigger buildings under factory conditions is still a dream for many, but one client got an office like that. A 10-storey high office building was fully assembled in a factory. After completion it was shipped to its foundation over a distance of 25 kilometres. The circumstances were ideal. The building was to be erected only 100 metres from a big waterway. A workshop for off-shore construction was found prepared to build the office building. And the client was the world leader in big transports. This client shipped the building himself to its foundation. The costs of transportation were never disclosed. It is likely that the client was prepared to make a show with his new offices. A demonstration of what his company could. But nevertheless here is a proof of what is possible in the field of off-site production. In countries with less water ways this example may be not relevant. There for another option for big transports may be mentioned here also. In Germany a new airship has been developed based on the principles of the Zeppelin concept. This airship will be marketed under the brand name of Cargo-lifter. It will be designed to carry a pay load of up till 160 tons. Enough to transport homes and small offices. We should not too easily conclude that off-site production is limited by the possibility to transport units over public roads.

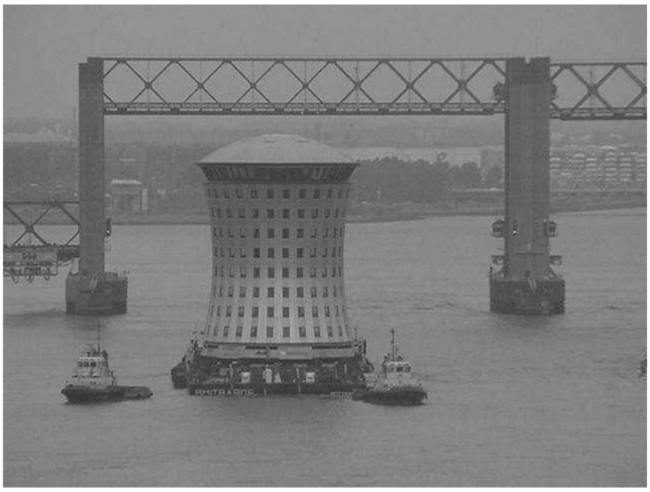

Figure2: A fully factory made office on its way to the foundation.

3. The clients response

The question to be answered is now: Did the supply-side of the market understand what their clients really wanted? Did the industry respond adequately? Were the new processes and products proposed to the market really an effective action?

3.1 Response to mass customisation

To meet the definition of mass customisation it is required that the continuity, which is a characteristic for industrial production, goes together with the ability to produce in accordance with the personal specification of the client. Of course there must be a balance between the two aspects that at first sight seem incompatible. The automotive industry proofed in past decades that mass customisation is not impossible. At building sites the ideal of mass customisation is still far from achieved. Where contractors offered a list of alternative many of these alternatives were only available for early buyers. Clients had to make choices while the contractor was still in the foundation stage. In a traditional process decisions on the location of pipes and outlets are already made when load bearing walls and concrete floors are cast. Some contractors and developers offered alternatives without really changing their process. They just expected their site-officers to deal more flexible with late requests for modifications. It only caused tension in project teams and an interrupted process. When the construction process is not basically changed to allow decision making in a late stage, the offer of alternatives to the client's choice is not a real way to client focussed construction. But clients highly appreciate the idea. Alternatives within the framework of mass production on site are a good strategy for client focussed construction.

The Smart House concept is an example of a completely new process. Though the decision making by clients is optimized here the marketing appeared difficult. Reasons found are the fact that the concept is rather luxurious. All in prices of over 700 thousand Euros per house were expected to be acceptable for a certain part of the housing market. It turned out to be too expensive for the quality offered. Apart from that the marketing focussed on clients for a high tech image. The market for such an appearance did not appear big enough. It can be concluded that client focussed concepts are appreciated, but not at any price.

The 7 heavens project, mentioned above, met also marketing problems. In a research project focused on this project [5] was found that tenants were reluctant to take responsibility for the coaching of their own architect. Unlike private builders they do not plan to live in an apartment for the rest of their life. They look only a few years ahead and expect to move to a single family house or elderly home after that period.

A problem for clients for mass customisation is their lack of experience to imagine how the rooms, shown in 2-dimensional drawing will look in real life. Introduction of 3 dimensional virtual reality presentations will facilitate the decision making process for clients. What we see is that many project development companies with private clients are introducing now 3-D technology into their marketing. On the Internet clients are invited to experiment with the available alternatives. For mass customisation with 3-D supported decision making a great future is expected.

3.2 Response to prefabricated elements

The market reacted very positive to the new floor systems. A great deal of the market for concrete slabs is now supplied with these newly developed products. It allows contractors to postpone the moment where no alternative cabling routes can be chosen any more. Clients of course appreciate the postponed deadline. If they also will use the possibility to change cabling later, after some years of occupancy, is something the future will learn us. A recent survey by the University of Aachen concluded that many tenants prefer to consider moving to another house rather than rearrangement of partition walls and cabling while the investment in this flexibility is considerable. [4]

The so called “computer floors” are already a well known feature in the market for office buildings. In housing the concept was up till now seldom applied. The costs were considered too high for that market. The recently introduced new products based on steel beams and removable lids appear to fit well within the budget of housing clients. A growing number of projects is applying such systems.

In respect of facades tenants appeared not interested to invest in the facades of their own apartment. The exterior appearance of an apartment building should be dealt with as a whole, not per floor. Investing in a section of the façade of an apartment building does not increase the value of related apartment. So owners prefer an investment in the interior of their apartment rather than in the exterior.

3.3 Response to prefabricated components and units

The market for prefabricated houses, either build with pillar slab systems or with voluminous units does not yet grow. The market share in The Netherlands for these types of houses remains at approximately 2%. Encouragement by the government is not enough to boost demand. Lack of land for housing and lack of enthusiasm to take the responsibility are constraints. And most important, the prices of prefabricated houses are not substantial lower that the prices of traditionally produced houses. If the manufacturers of these prefabricated houses could produce higher volumes prices could certainly go down tens of percents. Here a breakthrough could be enforced with some public support

4. Conclusions

Clients are not satisfied by the actual supply of standard solutions to there demand for housing. Clients want better quality, flexibility and a choice from a variety of alternatives even when the project is already close to completion. But most clients are reluctant to take responsibility for the design process themselves. If they really are prepared to take the lead themselves then are best served by small contractors and local architects. Also suppliers of prefabricated houses are an option for these clients. But a vast majority is not ready to take the lead in their own housing project and favours the products of mass customisation. They want a standardised product, with a wide range of options to personalise their homes. Flexible systems are appreciated, but clients cannot afford to pay much extra for such an concept.

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Understanding the Construction Business and Companies in the New Millennium

The world around us is full of different new management and improvement paradigms each of which has certain merits when we are trying to enhance operations. In the old business paradigm the words, competition and competitiveness, summed up the dominant mind set. Increasingly, these words are being replaced with terms such as partnering; openness; dynamic; interconnected; living qualities. These terms describe another mind set in which co-creation without boundaries is essential to the creation of new opportunities.

This book addresses characteristics of modern construction business and its live appearances. The topics cover characteristics and performance of modern construction business, shaping companies with new managerial solutions, organisational studies and innovations, human resource management, means for improved competitiveness and industrialization in construction.

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Kalle Kähkönen & Janne Porkka

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SECTION IV: Modelling and understanding added value

Preface

This book addresses company management and economics for the AEC sector. Globalisation and global operating companies are our starting points for getting an improved understanding on the dynamics of the live business and factors affecting on it. Basically construction businesses in different countries are local with its constraints, possibilities and other characteristics. Behind this scene the actual business operations and companies involved can be often to a great extent internationally integrated. This situation has created a new set of factors, actors and drivers, which are affecting on decision making on different decision making levels. How sufficiently or insufficiently we then understand or even identify the actual existence of the changed business environment? It looks obvious that we first need improved thinking and structuring principles. Based on these principles new business modelling techniques and applications can be developed.

Environmental concerns and ageing population are also affecting the whole AEC sector. These are examples of change factors that are forming gradually around us and having impact on wide variety of businesses in our societies. For the AEC sector this situation shall create new demands relating both to the end product and to the company operations and procedures.

Whereas the emerging business environment is increasingly global and complex it provides more new positive business opportunities. In particular, it seems that now there is a lot of room for integrators that can promptly adopt new trends, take grip of new business drivers, put together different players and their products for successful projects and business operations. However, behind of these manoeuvres there needs to be well-established expertise and understanding on the business environment where we are operating.

We hope this book shall be a source of new insights and solutions that can help us to understand better the modern AEC sector. It includes 30 papers from four continent providing a global view of various aspects of interest in different countries.

Kalle Kähkönen
Janne Porkka

VTT - Technical Research Centre of Finland

Helsinki, June 2005

Section I

Lessons from global construction operations

The Synergy Between Business and Global Drivers in Futures Planning for Construction Enterprises

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Abstract

Construction enterprises are driven by short-term business pressures yet they need to plan for the future. The global drivers are much more medium to long term and have a greater impact on the markets, rather than the enterprise itself. There are different time perceptions for different size enterprises which are heavily influenced by the strength of the balance sheet and the growth opportunities in the markets in which they work. Enterprises cannot afford to ignore the drivers that will impact upon their markets if they want to achieve sustained competitiveness.

Keywords: construction business drivers, global drivers, competitiveness, futures

1. Introduction

All construction enterprises plan for the future. "Although we cannot know what will happen in the future, we can still have expectations and make preparations." (Cottle, 1976). There are enterprises that make things happen, there are enterprises that see things happen and there are those that wonder what happened! Enterprises in the construction sector are frequently criticised for taking a short-term approach, furthermore, they are criticised for failing to invest sufficiently in research and development. The implication of the criticism is that enterprises do not take sufficient account of the long-term future.

Internationally, there is no shortage of foresight studies and reports forecasting the future for the construction sector. Very few consider the business case within their visions. Enterprises are driven, in part, by the business agenda; they need a way of looking to the future that incorporates the business case, thus making futures studies more relevant to construction enterprises.

All enterprises have a corporate strategy and a business plan looking 1-3 years into the future; some even look 5 years into the future. A competitive industry or organisation must be innovative and forward-thinking, without a long term approach sustained competitiveness will be difficult to attain. Construction is predominantly project-based with project teams basing decisions on short-term alternatives, because they have more information regarding the present and immediate future than the long-term future, whereas future studies are much more long term. The major criticism of future studies is that they often fail to take account of the business case.

This paper considers two research questions:

1. What is the relationship between the global drivers and the business drivers that are likely to influence construction enterprises when looking to the future?

2. The future involves a time dimension, how does the perception of time and the planning time horizon impact business strategy and competitiveness?

2. The sector

It is convenient to treat the construction industry as one sector. In reality, the sector comprises four parts: 1) the consultants (architectural, engineering and cost), 2) the construction enterprises who focus on production (including the specialist trade contractors), 3) the manufacturers and suppliers of components, equipment, plant and raw materials, and 4) the service providers to the sector (lawyers, accountants, insurers, bankers, financiers). Even within these groups there will be sector-specific enterprises that will specialise in one part of the sector, such as repair and maintenance.

Globalisation has changed the way business is conducted, with the mobility of labour, capital and goods. Increasingly, shareholders can be from overseas, and goods are sourced from suppliers in low cost economies. Capital has become transnational. Even within enterprises there is a range of stakeholders win the sector, each with different motives and goals. For example, the shareholders of the company will have financial performance as their main goal, whereas the clients will be seeking lowest costs.

3. Looking to the future - the global and business drivers

3.1 The global drivers

The nine global drivers used in this research came out of an extensive literature review fro which the following drivers were chosen as having the greatest impact on the construction sector:

1 Demographics and ageing
2 Climate change, sustainability and environmental pressures
3 Urbanisation, growth of cities, and transportation
4 People, safety and health
5 Rapid technological and organisational change
6 Vulnerability, security, terrorism, corruption and crime
7 Globalisation of economies and business

8 Information, knowledge and communication

9 Governance and legislation

Global drivers do not recognise national boundaries. They are connected by a complex web with some connections that are obvious, and others not. For example, demographics and ageing will have an impact on urbanisation and transportation because of people's changing lifestyles, the greater mobility of labour and an ageing population. Other connections may not be so obvious; such as, rapid technological change may increase the demand for energy and other natural resources and so become interlinked with the climate change, sustainability and environmental pressures driver. Drivers may mutate, changing their nature, their impact and connections of the driver.

Enterprises cannot ignore the global drivers, but their focus is on the business drivers and how they can maintain profitability, and customer and shareholder satisfaction, whilst at the same time facing, managing and implementing change. The business drivers tend to be short-term whilst many of the global drivers are of a long-term nature. A further complication is that the sector is made up of a range of enterprises of different sizes and types, each with different time horizons according to their size, type and market.

Demographics and ageing

Demographic changes are impacting the world with age distribution having significant effects on economic growth. The majority of the world's older persons reside in Asia (53%) while Europe has the next largest share (25%). One in every 10 people is now aged 60 years or older; by 2050, the United Nations projects that it will be 1 person in every 5 and, by 2150, 1 in every 3 will be aged 60 years or older. Figure 1 shows the ratios of the working-age population (15-64) to those 65 and over, in 2000 and 2050.

Ageing populations in the developed world are having considerable impact on the construction sector workforce, with a number of challenges to be faced as the workforce is increasingly made up of older people, and fewer young people are available for employment. The sector already faces problems of recruitment, retention, and retraining and so cannot ignore the challenge of an ageing workforce. An ageing population as customers of the industry will also have an impact.

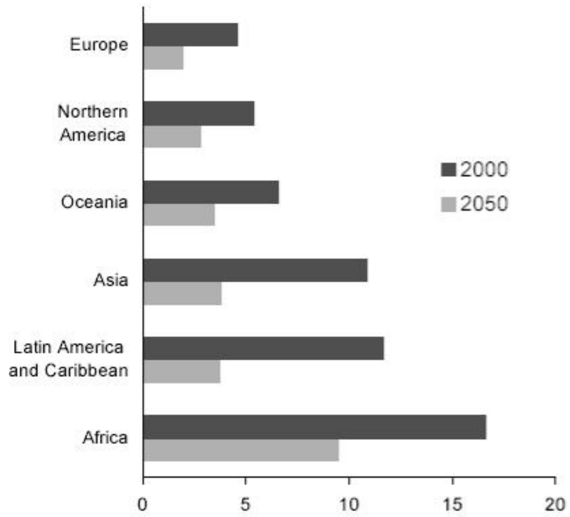

Figure 1: Ratio of number of people aged 15-64 to those aged 65 or over in major areas of the world, 2000 and 2050 (Source: UN (2002))

<u>Climate change, sustainability and environmental pressures</u>

"Climate change represents an unprecedented and highly complex threat to long-term economic interests across the spectrum of finance and insurance industry activities." (UNEP, 2002, p4). Global environmental problems are high on political agendas with more environmental legislation at a national, supranational and international level. Ozone depletion, pollution, depletion of resources, and global warming are common topics of concern.

Sustainability and its associated environmental pressures is changing construction. There are push-pull elements with legislation and taxation providing the push, and the pull in the form of business motivation to achieve less waste and greater energy efficiency, thus reducing costs.

<u>Urbanisation, growth of cities and transportation</u>

Growing urbanisation is creating congestion and a decaying infrastructure is not meeting increased demand. In the UK, the demand needs to be met by increased density and use of brownfield sites. People are more mobile, using roads, rail and air more frequently. The current stock of infrastructure cannot cope and modification, modernisation and refurbishment will be required to the existing infrastructure, with particular emphasis on environmental impact.

There has been a change in the financing over the last few decades with a shift from public to private sector financing. The number of BOT, BOOT, BOO, and public/private partnership projects has increased (World Bank, 2003). The 'public good' nature of infrastructure projects makes them sensitive to social and political pressure. The mechanisms to attract private finance into infrastructure provision are becoming more complex and the length of the concessionary period means that enterprises have to adopt a whole-life, long-term strategy.

People, safety and health

Human capital is an increasingly important asset; the tacit knowledge of a business rests within its workers. Therefore, the health and work environment of construction workers is important. The overall 'cost' of accidents and near misses on a construction site can amount to some 8.5% of the contract price (Minister of State for Work, Department for Work and Pensions 13 September 2003). A UK Health and Safety Executive report calculated that one third of all work fatalities happen in construction and construction workers are six times more likely to be killed at work than employees in other sectors (HSE, 2003).

In the developed world, new construction processes will lead to greater mechanical assistance for construction workers and the elimination of dirty, dangerous and debilitating activities through the provision of advanced mechanisation. They will benefit by having safer sites and better worker health due to better ways of working and job satisfaction due to changes in the nature of the work accompanied by new rules for site management procedures. In the developing world, labour is much cheaper and the pressures to mechanise are not so great.

Rapid technological and organisational change

Technology impacts upon all people, products and processes in an economy; its application is one of the drivers of change for the next wave of economic growth. Information and communications technology (ICT) enable more efficient processes such as e-business, auto-ID, information management. Wireless technology and telecommunications is advancing at a very rapid rate. Increased bandwidth is allowing faster and a wider range of access to internet-based processes.

There is a trend towards more small businesses, outsourcing specialist activities and changing management methods (European Agency, 2002). Rapid technological innovation often leads to changes in demand and consumer expectations and so requires organisational change to meet those demands (Singh and Shoura, 1999).

Construction organisations are faced with information that is increasing and becoming more complex; project managers can spend up to 70% of their time dealing with data - generating, managing, sending, collecting and analysing it (Fisher and Yin, 1992). Solutions are being sought to cope with the level of paperwork associated with projects (Thorpe and Mead, 2001). Research has shown that construction costs can be reduced by as much as 25% if information is transferred effectively (Baldwin, 1996; Davidson 1990).

Vulnerability, security, terrorism, corruption and crime

A growing concern about the threat of terrorism, particularly since 9/11, has led to changes in construction, such as better and stronger structures, and personal safety measures. Different designs are being studied that minimise the impact of bomb-related threats. Structures are being designed such that a column collapse would only result in the collapse of a single floor or area without causing the collapse of the floors below it. Reinforcement of the columns in existing buildings by the use of fibre glass or carbon fibre materials is being researched and also how to minimise the impact of shattered glass. Experts are investigating the effects of the introduction of an aerosol agent into the heating, ventilation, and air-conditioning (HVAC) system through the development and installation of devices that are designed to kill micro organisms or filter harmful chemicals.

Corruption increases the uncertainty of doing business because it erodes the rule of law and is associated with high levels of bureaucratic red tape. Some describe corruption as a “tax that adds to the cost of doing business”. Various business surveys have concerned themselves with the prevalence of corruption in everyday business operations. An empirical analysis of transition economies in Eastern Europe and Central Asia showed that investment levels in countries with high levels of corruption were 6% lower on average than in countries with medium levels of corruption (21% and 27% respectively) (The World Bank, 2000).

Globalisation of economies and business

Globalisation has increased the importance of competitiveness. It has shrunk the world, with transactions undertaken electronically around the world 24 hours a day, every day of the year. This greater connectivity is evident in the mobility of goods, services, labour and capital. Goods are increasingly being sourced from around the world, often from low-wage economies; for example, materials from China and design being undertaken in offices in India, Pakistan and China. This will lead to a rationalisation and consolidation in construction materials and components supply. Globalisation has brought new ways of working as overseas firms continue to acquire/collaborate on projects, introducing changes to the design and construction; the creation of economies and businesses that are interdependent.

Greater transparency in reporting business results is being required by investors. There is an increasing need for companies to maintain public confidence in the legitimacy of their operations and business conduct - a licence to operate. Corporate social responsibility is becoming more important, particularly to major companies.

Information, knowledge and communication

The growing importance of technology, knowledge, and skills is crucial with the move towards knowledge-based business and knowledge technology becoming central to all business. Therefore knowledge management is of equal importance with the ‘information overload’ that exists. The level of performance of the world’s best is constantly being raised as a result of innovation in communications, technology and learning. The centre of gravity in business success is shifting from the exploitation of physical assets to the realisation of the creativity and learning potential of people. More than ever, people and relationships are the key to sustainable success.

The future is where all electronic devices are ubiquitous and so are networked and every object, whether it is physical or electronic, is electronically tagged with information pertinent to that object. The use of physical tags will allow remote, contactless interrogation of their contents; thus, enabling all physical objects to act as nodes in a networked physical world.

Governance and legislation

Construction is faced with increasingly complex regulations and greater government intervention through legislation, taxes and tariffs. Standards and codes are very important as they directly affect the future public safety and affordability of every public building. They afford protection from substandard housing, poor sanitation, and unnecessary risk of fire or loss of life from natural (or man-made) disasters.

Codes and codes enforcement can either facilitate or restrict the introduction and use of safe, durable, and innovative building products, technologies, and processes. In that regard, codes and codes enforcement also can either enable or make it virtually impossible for building products manufacturers to aggregate their markets, which could reduce the cost of their products through volume production. Market aggregation thus enables product manufacturers to more readily compete in the international marketplace. The adoption of uniform codes with few (if any) technical amendments across Europe allows greater international competitiveness. The USA has placed a high priority on the internationalisation of the American standards in order to maximise their global competitiveness.

3.2 The business drivers

The views of the sector business leaders were sought in identifying the main business drivers over the next five years:

1 Stakeholder pressure

- Need to increase alignment between the desires of executives and shareholders - if the shareholders do well, the executives do well.
- Executive remuneration packages need to be based on a total reward basis, with strong incentivisation
- Demand for more transparency and openness
- Shareholders do not like excessive risk, the share price reflects the organisation’s level of risk
- Share ownership has shifted with more overseas involvement (see Figure 2). The figure shows a more diverse ownership, with an increasing overseas involvement.

2 Human resources/people

- Ageing workforce with the challenge of the skills gap and shortage of labour
- Health and safety with a zero tolerance towards accidents
- Recruitment and succession planning

- New collaborative role of unions
- Incentivisation of the workforce

3 Profitability

- Reduction in EBITDA across the major firms – EBITDA has fallen from around 3% in 1990 for the top 38 international construction organisations to 1.6% in 2004
- Pressure on CEO to deliver more for less in a shorter time frame. CEO life in post is decreasing
- Profits must reflect risk – the industry average should be 4-5% to have a sustainable Profit/Earnings Ratio

4 Merger and acquisition pressures

- More mergers and acquisitions creating consolidation in the sector
- Importance of a strong balance sheet and expertise for PPP/BOT/PFI

5 Improving performance (design/production/productivity)

- Need for improved productivity on site
- Design liability has become a major issue. Consultants have weak balance sheets
- Fee levels have become too low for the level of design work expected leaving detail design to be undertaken by contractor/specialist

6 More risk being managed

- Unreasonable contract conditions with standard contracts being modified
- Safety legislation being increased to place responsibility on designers, owners, as well as construction organisations
- Everyone is getting smarter at risk allocation
- Insurances and Bonds getting more expensive

7 Competition from low-wage economies

- A new wave of construction firms - the real threats are from material supply in China and design in offices in India, Pakistan, China
- Growth of the Informal sector workforce

8 Competitiveness

- We need to compete by exploiting technology
- Better productivity and performance will drive down cost
- Performance and its measurement – with so much benchmarking we have forgotten how to measure performance
- Safety and finance are a real competitive advantages

9 Markets

- New methods of procurement with PPP/BOT/BOOT/PFI
- Procuring on value rather than price
- New importance of the housing sector
- A focus on local markets and being a local player in Europe

10 More bureaucracy

- Corporate governance and reporting – there are around 60,000 pages of corporate governance legislation
- Adoption of IFRS standards for accounting
- US Sarbanes-Oxley legislation is coming to Europe
- Pension legislation with pension fund provisions on the profit and loss account
- Environmental legislation
- Codes of ethical behaviour
- Tax legislation on payments

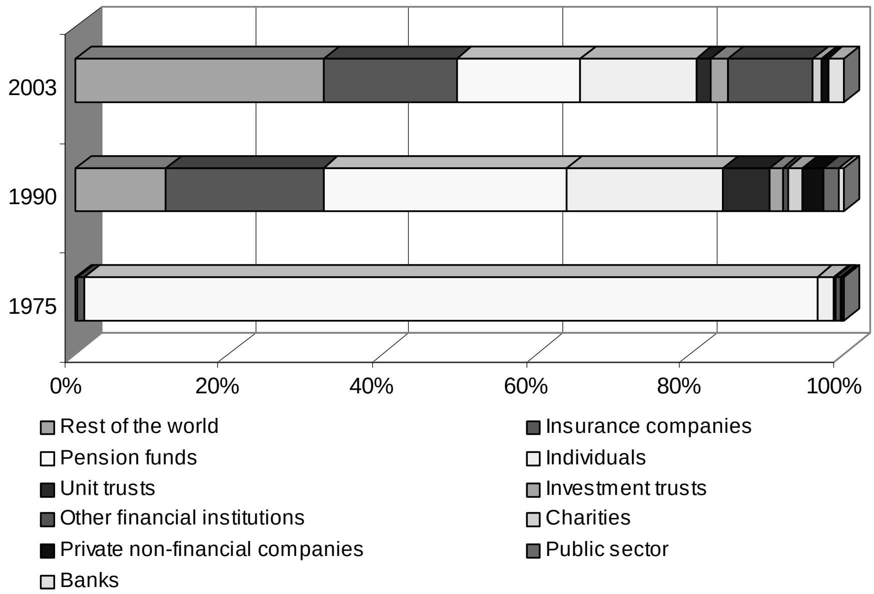

Figure 2: Total equity owned by institution (%) – UK share ownership (Source: Office for National Statistics, 1975, 1990 and 2003)

The business drivers will change over time. A key question is "How do the business drivers relate to the global drivers?"

4. Mapping the business drivers against the global drivers

Figure 3 shows the business drivers mapped against the global drivers, that are primarily seen as a market opportunities, they are not seen as core to the business drivers. However, some have more influence on the business than others. The ‘time’ column is a description of the global driver’s time horizon i.e. short, medium or long term. The matrix reveals two interesting points:

- The highest ‘scores’ when matching the business drivers to the global drivers are for rapid technological and organisation change, globalisation of economies and business and governance and legislation.

- None of the long-term global drivers such as demographics and ageing, climate change, and urbanisation ‘score’ highly against the business drivers.

Why should a construction enterprise be concerned with both business and global drivers? The answer is sustained competitiveness. If an enterprise is only concerned with the business drivers, taking them into account in any strategic planning may well increase or establish their competitiveness. However, to achieve sustained competitiveness, the impact of the global drivers needs to be considered as they will ultimately impact the organisation and its environment. The difference between the business and global drivers is their time horizon.

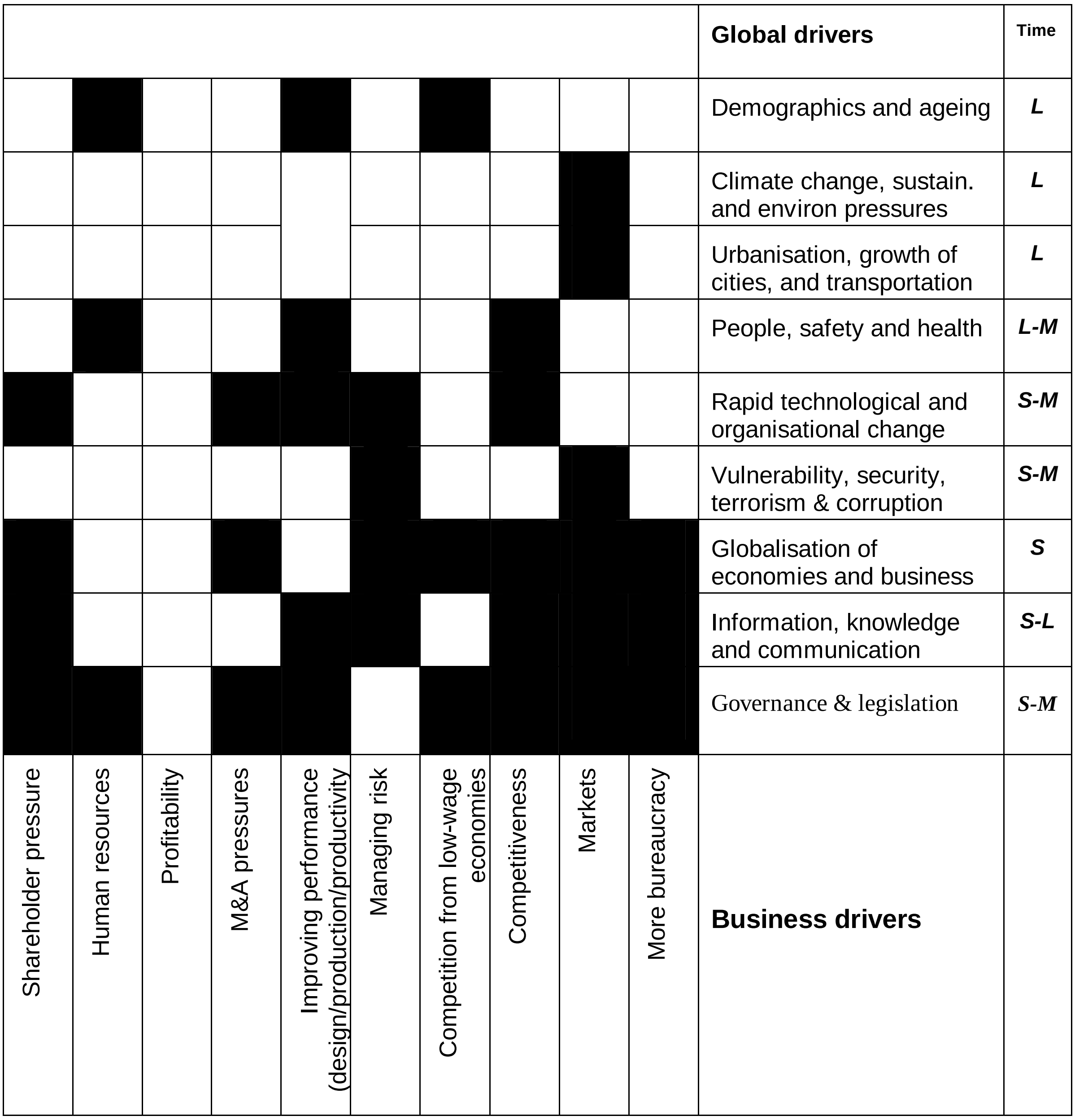

Figure 3: The business drivers mapped against the global drivers

5. Time horizons and the perception of time

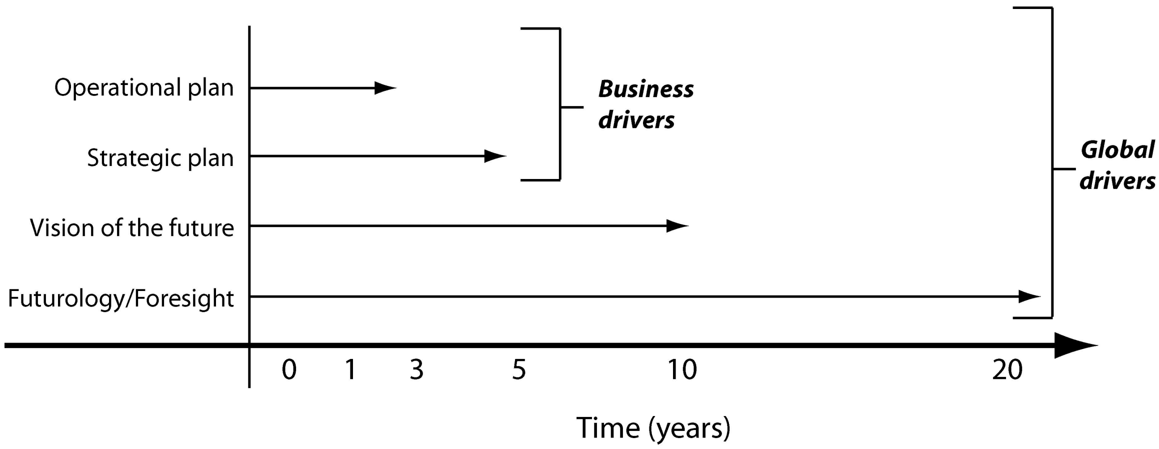

Figure 4: A business strategy timeline

Figure 4 shows the different ways of looking towards the future undertaken by businesses and the time horizon of these plans.

As we have seen from the mapping exercise, the business drivers impact the short-term plans, whilst the global drivers impact the longer term planning. Each of the stakeholders associated with the business also have their own perceptions of time - see Figure 5.

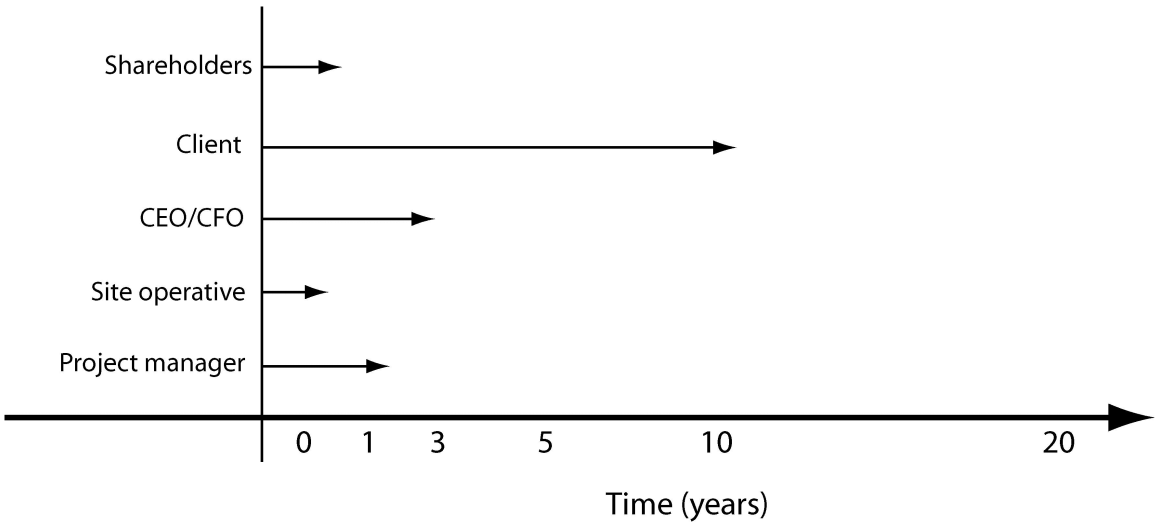

Figure 5: The timeline of some of the stakeholders

The perception of time when considering the future is strongly influenced by the size of the enterprise, the strength of the balance sheet and the growth opportunities in the markets in which it works. There is a range of futures, not just one. Enterprises' perception of time are different, some put more emphasis on the past and the present, others see the future as being more important. This is illustrated in Cottle's (1976) circle test which ascertained how people relate to the past, present and future. Figure 6 shows the different 'circles' for a large and medium-sized construction enterprise.

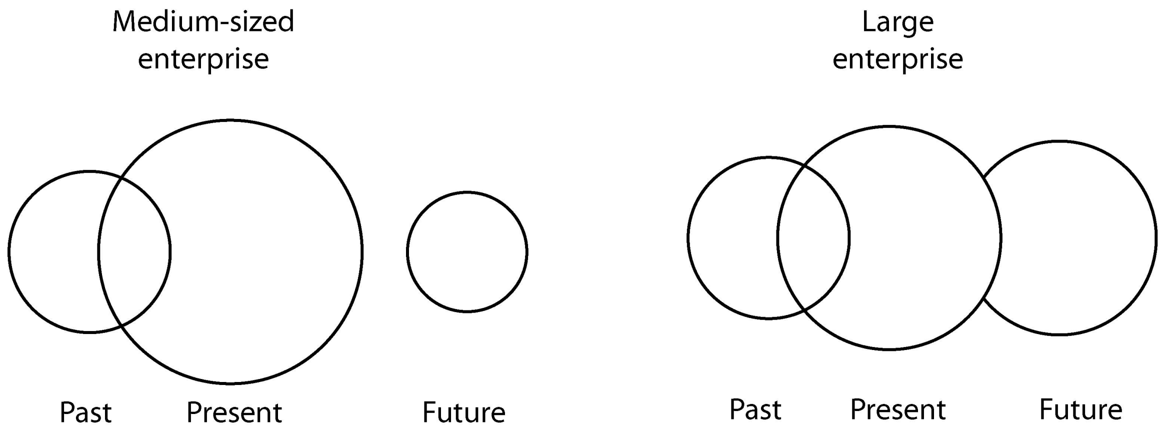

Figure 6: The timeline of some of the stakeholders (Source: Based on Cottle, 1976)

The size if the circle is a function of the importance the enterprise places on the past, present or future. The connectivity of the circles shows the relationship between the three. Our research suggests that most SMEs relate more to the past and present than they do to the future. This short-term view reflects the financial position and the need to maintain cash flow. In futures research the temporal relatedness is very different to the enterprises with a larger future circle that is disconnected form a small present circle and even smaller past circle.

An organisation's knowledge is all about the past, yet its decisions are about the future. Therefore, deciding how far away that future is and planning towards it is important. Corporate planning needs to take account of the different time horizons and to move away from a culture that is heavily biased towards single-point forecasting.

6. Conclusions

One of the main differences between business drivers and global drivers is their time horizon. Business drivers tend towards the medium and short term, they revolve around shareholder and client satisfaction underpinned by the need for the business to be profitable and grow. They have changed little over the past twenty years. Global drivers are short to long term and they change over time, mutating and creating a complex web of interactions that have broad consequences. The long-term nature of some of the global drivers means that many organisations do not take them into account in their forward planning, yet in order to sustain competitiveness, these drivers must be recognised in the organisation's planning process.

The need to sustain competitiveness means adapting faster to the increasing pace of the business world. The ability to change quickly is affected by a) the ability to predict change, and b) the ability to quickly respond to change with effective strategy and execution. Predicting change means looking to the future and recognising the synergy between business and global drivers and their temporal dimensions.

Our recommendation is that enterprises must incorporate futures thinking into their plans and understand the complex interactivity that will ultimately influence their business.

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The Impact of Collaboration on Procurement with Particular Reference to China

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Abstract

During the last two decades the world economy has experienced an unprecedented transformation with the convergence of business trends and a proliferation of technology, reorganization of economic boundaries and intensified global competition, which have profoundly altered market ideas about firms, markets and competitive environments. Product and process life cycles have become shorter, removing product-based advantages and forcing firms to develop continuous streams of innovations on international platforms. The development of firms to adapt to these market changes have required them to form collaborative ventures to ensure that speed to market is achieved and core competencies are appropriate and exploited. This worldwide focus has impacted on construction where home country relationships now need to be accessed on a world wide basis causing not only regulatory and protectionist attitudes to be overcome but also adaptations to the culture practises of host countries. The objectives that need to be addressed concern achieving synergy in the new market phenomena while, at the same time, showing sensitivity to the cultures of the host countries. The issues are investigated through case studies, which indicate how reconciliation of different approaches can be achieved and the lessons that can be learnt. It is evident from studies of individual cases that culture is a critical element of the process of project delivery. Understanding and accommodating culture in the mode of procurement is essential in establishing, communicating, and achieving the goals of a project in an environment that is dynamic and subject to the intricacies of officialdom.

Keywords: China, Collaboration, Construction, Culture, Procurement

1. Introduction: Collaboration Formation

1.1 Entering New Markets

With the changing Global economy and the integration of global markets, companies seek access to cheaper manufacturing and alternative customer bases. China, with its rising living standards and ready supply of labour, offers international firms opportunities no longer available in home markets. Many physical barriers which existed in this market are now merely symbolic, as what was a planned economy with major legal and regulatory obstacles (tariffs; capital controls; restriction on products, markets and labour) moves towards an open structure, albeit one with formidable constraints on interaction (differences in languages; standards; cultures). Therefore, domestic companies enjoy greater access; outsiders must develop skills to overcome the boundaries via either direct investment or alliances. Globalisation enters the arena where companies aim to create markets for specific territory-orientated products or create a global standard. The deregulation and privatisation of government services and utilities has facilitated the introduction of foreign invested infrastructure thereby allowing construction firms to lever intangibles rather than just physical capital.

1.2 Introduction to the Chinese Economy and Its Growth Potential

China is the most populous country in the World with densities varying from 2-persons/ square kilometres in Tibet to over 2100 per square kilometre in Shanghai. By the end of June 1997, China's economy had grown almost 10 percent a year for two decades. Trade with other nations reached US $260 billion for the first 6 months of 1999 [1]. By the end of 1998, more than 120,000 foreign-funded enterprises with 18 million employees were operating across China. There were 1.36 million private enterprises employing 17.84 million people by the end of 1998 [1]. Total foreign investment was US$ 202 Billion [2]. The international Monetary Fund (1997) [2] predicts that if China can sustain its current growth rate, its GDP will reach the total GDP of the European Union and the USA by 2014.

The construction industry in China is one of the biggest in the world, employing some 35 million workers (8.8 million were employed in 1978). The annual value of residential and commercial construction in China is about RMB 550 billion (67 billion US dollars). China's annual expenditure on public infrastructure is about RMB 600 billion. The open market has created an unprecedented requirement to juggle time, cost and quality. Under the Ninth five–year plan for 1996-2000 and the long-term objectives for 2010, China has called for opening to the outside world to be intensified. China requires capital construction worth US$ 1000 billion, mostly infrastructure. While the requirements are for technologically advanced projects, investors require overseas designers, specialist contractors and suppliers to work together with local organisations. To comply, a change in law to allow foreign contractors to register as main contractors is in effect. This, in addition to the acceptance of the rules and regulations of the World Trade Organisation (WTO) demonstrates that China has committed itself to levelling its trade and investment barriers.

The effect of WTO entry can be seen where foreign architectural and engineering design practices are permitted to work in China, provided that their staff comprise professionally qualified people working in the same fields as their home country. For construction companies, there is a change in the rules whereby foreign contractors can establish Wholly Foreign Owned Construction Enterprises (WFOCE) and compete with local companies – although the chances of competing on domestically funded projects are limited. Other regulations recognise construction joint ventures with Chinese companies. With such relaxation, China is making construction procurement more transparent and accessible to foreign clients with special needs. For foreign construction companies, there must be large investment up front if they wish to participate in this market – the grading of the construction entity follows PRC requirements and, therefore, only major companies have the resources needed.

1.3 Rise of Alliances – the concept of collaboration

Collaboration is a reaction to the changing external environment where ‘traditional’ economic considerations must be supplemented with further thinking, typically on culture, knowledge transfer, risk apportionment etc. This reaction is to mitigate the extent and effect of risks which threaten future economic benefits.

In China, overseas companies have found that collaboration with indigenous construction entities is one way to cut through the complexities and difficulties that arise not only due to culture but also bureaucracy. A collaborative alliance is an agreement between firms to cooperate in reaching an objective without regard to the legal or organizational form. This definition accommodates the myriad arrangements from handshakes to licensing, mergers, and equity joint ventures [3]. With regard to entry to the China market, it is this direction that many major firms have taken e.g. Lucent, Intel, IBM, IKEA. Entry into China is skill dependent, as clients require contractors which are familiar with both the market and their expectations. Collaboration is popular as these corporate partners are less interested in short-term ventures designed to save a few dollars than in long-term alliances where gains are made over many years.

Often, collaboration is used to cope with the competitive tensions engendered by a client’s rapid technological gain and geographic procurement requirements. Collaborations attempt to reduce conflict by cooperation with competitors or gaining market power through alliances [4]. Companies use collaborating techniques because:

§ Resource pooling provides a source of efficiencies, especially where the construction company has established trust with the client to become the builder of choice –where the builder gains a guaranteed workload and the client obtains a trusted, dependable contractor versed in the client’s requirements. (IKEA and Skanska, both Swedish companies whose international expansion has been in tandem.)

§ Industry and regional alliances from home bases enable organisations to enter global competition. A strategic alliance may be a way of entering a new market, or of capitalising on the strength of another organisation. This is demonstrated where a client who wishes to develop operations in China, engages an alliance construction company rather than employ locally – even if this alliance construction company has little experience in China or the client’s operation requirements.

- Response to different political circumstances in different cultures is of prime importance to those who operate globally. Globalisation presents a challenge to the strategic management of business operations i.e. for a company to keep track of all the changing technological, economic, political-legal, socio-cultural trends around the world, networks/collaborations enable strategies to be developed more logically. Alliances with local players have a distinct advantage over traditional multinational company structures in this respect and can adapt faster to the changes that occur. (The services that Gammon Skanska offered used the benefits of its global position to draw on home country alliances to develop business in regions such as China. This ensured that the line of responsibility remained where the client had the most comfort and could be threaded back to the home country.)

If planned and managed effectively, collaboration provides mutual benefits to the parties; examples are [5]:

- Enable overseas expansion (client supported) and provide access to new markets.

- Develop and improve operations, facilities and processes, provide access to new capabilities, new knowledge and new technologies; scope of services is increased.

- Decrease risks and enable relatively rapid adaptation to changing competitive market forces with the client leading.

- Create new opportunities under increasingly intense global competition with a global network of skill which can be utilised to offer enhanced services to clients.

Cooperative organizations are often more effective at competing in a global setting; collaboration allows the combination of independent organizations under one distinct, competitive unit [6]. Combining independent organizations with different competitive/comparative advantages can result in a greater overall advantage and allow the new organization to access the global market [7]. This process has the potential to give the new organization advantages of both economies of scale and scope, as well as reducing the amount of risk faced by either organization separately [8].

2. Collaboration in the Construction Industry

2.1 Collaboration: the motive

“Firms have increasingly come to see in the globalization of competition four critical cross-border dependencies – economies of scale, in various parts of the value chain, that span national borders; competitive moves that have implications in more than one national market; opportunities to arbitrage country or location based advantage; and scope interdependence that permits firms to leverage across national borders learning related to products, markets and technologies that have an impact on their competitive strategies" [9].

The current business environment places stress on existing management structures where there is not enough money, time or personnel to be successful in all sectors and in all markets. To mitigate such problems, a more flexible approach is needed. The following corroborate the adoption of collaboration ventures:

§ Only 21% of the revenues of the top Asian, US and European firms were generated from core business in 1980. In 2000, the same companies generated over 70% of their revenues form core business. Companies that wish to explore opportunities outside their cores are increasingly utilising alliances [10].

§ Alliances are one of the top five factors driving market value in all industries; each partner's stock price increased upon the announcement of each new significant alliance [11].

§ Alliances are yielding, on average, 50% higher return on investment for the top 100 US companies as compared to returns on the core business [12].

In the global market, cooperative partnerships and alliances are proving a more productive way to keep companies growing. This development has mirrored the demand faced by international construction companies which are expected to offer clients home country satisfaction in an overseas environment – the broadening of services is a reaction to this demand. Under this scenario, companies like Gammon Skanska entered China, collaborating with clients. In undertaking construction projects, each relationship needs to be viewed individually as there is no standard format that can be applied for collaboration. Differences in the cultures of companies, projects, industries and countries bear on the success of a project. Thus, where organisations are attempting to improve their competitiveness by developing and bringing together new sources of skills in an overseas situation, the formation of new organizational structures must be understood from a cultural perspective. This understanding introduces new ideas and concepts thereby demanding a lot from the individuals employed who need to adapt to new ways of thinking to address the concerns of each party [7, 9].

2.2 Cultural Fit within Collaboration

Even where collaboration skills are embodied in the cultures of both companies and countries, they need to be expressed in the design of any collaborative entity. The organisational design must take account of the national/macro level; industry sector level, organisational and firm levels and the perceptions of individual managers. The cultural aspects need further refining in terms of the requirements of the groupings employed [13]. Swedish, American, Hong Kong Chinese, and Mainland Chinese all have different interpretations of how goals are gauged [14]. These fundamental differences in values, beliefs and philosophy of social regulation drive overt, manifested phenomena in a society. Collective actions are behaviour by members of a group for the sake of the common good [15]. It is, therefore, suggested that there are two systems of regulating collective action: relationship based and procedure based. A relationship-based system relies on the relational networks of the system (IKEA's style), whereas procedure-based regulatory systems rely on the formalization and institutionalisation of procedures (IBM and Lucent style). Some cultures rely more on relational means, while others rely on procedures, to regulate collective actions. For example, Chinese culture regulates many of the actions of its members using relational mechanisms, such as face and familial sanctions, whereas American culture relies more on formal, enforceable agreements, such as contracts and legal agreements.

2.3 Chinese Cultural Approach

Historically, Chinese society had no formal laws, only a formal network of powerful people guided by Confucian principles, as expounded by K'ung Fu Tzu 551 – 479 B.C. (Confucius), who emphasised the relationships between ruler and subject, father and son, etc. and defined who was to obey whom – although Confucius is often quoted in describing the culture of the Chinese, it is limited; Master K'ung did not have much to say about interaction with strangers (suppliers/contractors, customers etc.) and the profit motive of business was not considered a key principle, even rather suspected. The historical background to this thinking is that favours from authority could change daily engendering a distrustful society that relied on family ties as a way of doing business; this has developed where the informality of *guangxi* (relationship) is critical to the understanding of interactions – it is this which Western clients have difficulties comprehending and adopting. The gap in Confucian thinking is filled by Sun Tzu 500B.C., whose philosophy consists of many strategies for outwitting opposition –based on tactics of war and, often, cited by business schools. Lao Tzu 604 – 531 B.C. (Taosim) stresses the importance of action through inaction, of letting go and not resisting the way of achieving balance – the thinking fits well with the doctrine of the free market economy and comparisons can be drawn for acceptance of this approach in doing business – although governance issues, as developed in the West though contracts and external auditors, pose acceptance problems and conflicts with the idea of 'balance'.

2.4 Cultural Impact and Effects on Collaboration Strategies

The case studies investigate interplays between the parties on construction projects with focus on the external environment of China. The ambiguities of operating in a China environment create the need for flexibility. People across nations and cultures believe and behave differently; in construction, these issues are compounded by the interplay that must exist with an extensive array of highly differing participants (designers, subcontractors, etc.). Nations and cultures vary in terms of how they define specific phenomena, including behaviour, language and institutions – it is these factors that impact on the success of the collaboration as cultures interact.

The Western perspective of Eastern culture characterizes it as collectivist, large power distance, masculine and long-term; uncertainty avoidance yields diverse results [16]. In conducting business, Westerners focus on the attributes of the potential deal; Easterners focus on the attributes of the people involved initially, in order to evaluate the desirability of dealing with those people – again, the relationship aspect.

Two important factors, therefore, are identified; culture and network. The following culture-related factors need to be considered in collaborations:

§ Developing interpersonal relationships between the client, designers, and site management.

§ Familiarity with the Chinese negotiation process by all parties involved.

§ Understanding of Chinese thinking (process) from a foreign perspective.

§ Comprehending traditional Chinese management styles by acknowledgement of different ways of behaving, especially in achievement of consensus.

§ Acquaintance with Chinese criteria for employee evaluation and work assessment.

For networking-related factors, the following should be considered:

§ Effective communication from overseas with Chinese firms, understanding that the Chinese have been negotiating for over 5000 years and are well versed in procedures of communication.

§ Effective communication within China through language and/or appraisal of gaols.

2.5 Success of a Collaboration's Design

To ensure the success of organisational change over the long term, change leaders must install mechanisms that will promote and institutionalise change. Integral to this is the establishment of new organisational systems and structures that represent the new work arrangements and reporting requirements [4, 17]. Successfully implementing and sustaining the momentum for organisation-wide change demands a long-term strategic approach, incorporates both 'hard' (strategy, structure, systems, technology) and 'soft' (vision, values, behaviours, attitudes) elements. Effective change leaders use various methods to energise and enable people, operating at all levels of the organisation, to become involved in, and contribute meaningfully to, the change process. Strong and widespread interpersonal involvement, focusing on developing roles, responsibilities, structures, systems and rewards, is a critical building block for driving organisation-wide change. The relationship between collaborative alliances and corporate culture is a major determinant of the level of success of an alliance; for example IKEA has a corporate structure synonymous with a horizontal type of management whilst IBM has a more vertical type management structure [18]. The other important relationship is between national cultures which will affect the outcome of strategic alliances where organizations' management practices differ; e.g. one with Swedish and one with American attitudes, compounded by working together in a Chinese environment.

3. The Role of Alliance as a Competitive Strategy – How Gammon Skanska Operated

Global competitiveness requires simultaneous global-scale efficiencies, worldwide learning and local responsiveness – it is such a service which Gammon Skanska, through its global position, attempted to lever. As a single firm, resources were limited, therefore, alliances are sought to develop global competitiveness. Thus, strategic alliances were formed to acquire the desired strategic capabilities more rapidly. Weakness in corporate culture cannot be compensated by collaboration; within Gammon Skanska, the culture in Hong Kong was strong but was weak in China mainly due to the commitment and focus of the parent company. Alliances should not be used to compensate for cultural weaknesses, but to create competitive strength or/and a strategic position. Furthermore, an international level of analysis should include an understanding of a country's culture. Construction companies, like Gammon Skanska, attempt to improve competitiveness by developing and integrating new sources of technologies and skills, resulting in the formation of new organizational structures. Alliances are the answer for companies attempting to acquire such highly sought-after resources while maintaining vigilance upon other strategic priorities and enhancing their global competitive strengths as they share resources needed to enter new markets [7]. This process is not new to construction where subcontracting and seeking out specialist skill is the norm. In addition, international construction companies are not constrained by requirements of geographic locations in the same way as firms engaged in mass production, therefore, they must have a global/country presence to secure economies of scale, and have the physical and geographical characteristics most appropriate for efficient operation in those areas, complementing the culture and technical aspects with the requirements of clients.

3.1 Case Studies

Gammon Skanska was a construction service provider with a turnover of US$0.7billion employing over 1500 employees. The company was jointly owned by Jardine Matheson and Skanska AB. Jardine Matheson is an Asian-based conglomerate with worldwide business interests including property, hotels, supermarkets, consumer marketing, engineering and construction. These operations employ some 150,000 people in over 30 countries. Skanska is one of the world's leading providers of construction-related services and project development; it has an annual turnover of around US$10 billion and employs some 80,000 people, operating in 60 countries worldwide. Gammon Skanska, in China, has completed 80 projects in more than 16 cities, operating out of offices in Beijing, Shanghai and Shenzhen. Gammon Skanska holds a

National Grade A certificate issued by the Ministry of Construction in Beijing, which pre-qualifies it to operate as a general contractor throughout China.

3.1.1 IBM and Gammon Skanska

Facility of 22,000m2 is located on 50,000m2 green field site. The functional core of the building is a 6,000m2 clean room, which is certified at class 100 – 100,000. All standard mechanical and electrical systems are provided together with specialist processes for the clean room operation. 11 specialist subcontract packages and pre purchase of the major equipment by the company.

IBM's investment in Shenzhen was to construct a hard drive fabrication facility. The building required a high international design and specification. IBM employed international designers and Gammon Skanska to manage the project under a Construction Management contract, to retain control over the design while, at the same time, fast tracking the progress of the works. Gammon Skanska received a fixed fee for personnel plus a percentage for managing the subcontract packages. Gammon Skanska was chosen for its China experiences and familiarity with international standards; all the contracts were signed between Gammon Skanska the works contractors. Collaborating ensured that ambiguities were dealt with on a formalised basis with a reporting structure that was standardised throughout IBM. Interfaces with the local Chinese authorities and contractors were left to Gammon Skanska, using more informal negotiation. Due to the fast-tracking of the works, an effective system of cost control of the design and works packages was essential.

3.1.2 Lucent Technologies and Gammon Skanska

The facility has a gross floor area of 33000m2 on a 81,500m2 green field site, comprising a 15000m2 steel frame manufacturing area to house 6 SMT lines, 7300m2 single storey steel frame warehouse and 10,500m2 two storey concrete frame office and cafeteria. The project was constructed to international standards.

Lucent Technologies 50/50 joint venture was one of the initial joint ventures set up in Shanghai to take advantage of the telecommunications infrastructure requirements of China. Technology from USA was being used and manufactured for the Chinese market. This joint venture was rife with conflict between the three Chinese partners (50% holding) and the American partner (50%); all had their own agendas for the joint venture which impacted on the actual physical product. The American partners had an American Project Management team which was technically and commercially astute, the Chinese partner had their own Chinese Project Management team – conflict ensued. A compromise was made: Gammon Skanska was engaged as Project Manager, whereupon the focus of the development became completion. The procurement mode was based on a Project Management Consultant, with a remit to manage the preliminary design work (carried out in the U S), gain statutory approvals and develop the project from inception to hand over. This partnership demanded that the construction provider should satisfy the Chinese participants and the American partner. This role meant that satisfying both parties needed careful management and understanding of the relationship between Chinese and American perspectives. Lucent personnel required considerable time and expertise to assess the recommendations of the project manager and to expedite the actions needed.

3.1.3 IKEA and Gammon Skanska

A new IKEA flagship store in Shanghai develops the IKEA shopping concept. The building is developed on 39,842m2 of land (total floor area 69,000m2), comprising an underground car-park, sales area, restaurant with canteen and a five-story grade B office block (7900m2). The internal fit out reflects the corporate image of IKEA. The construction period was over 1 year, which was challenging for the size of project and client's requirements and was carried out by Gammon Skanska as design and manage.

Gammon Skanska's relationship with IKEA stems from a history of co-development, particularly in Sweden, to other areas of Europe and the world, where Skanska is the builder of choice for IKE. The procurement approach taken by IKEA was to purchase the land for development, then award the design and manage operations to Gammon Skanska; thus, making the construction company solely responsible for the Project. This relationship ensures that the IKEA concept is uniform throughout its operations. There is no formal contract for strategically aligning the two companies but the commonality of national culture combined with the company cultures have generated a history of the two companies providing services to each other.

3.2 Discussion of Results

The principal analysis uses qualitative information and is based on comparisons between individuals in the case studies. The investigation is exploratory, aimed at advancing propositions rather than drawing generalized inferences.

Alliances are designed to share risk and resources, to gain knowledge and to obtain access to markets. International alliances are "…cooperative arrangements, involving cross-border flows and linkages that utilize resources and/or governance structures from autonomous organizations headquartered in two or more countries" [19]. The general intent of alliances is to establish and maintain long-term cooperative relationships in order to compete more effectively with firms outside the relationship and initiate benefits for both parties. The case studies demonstrate that emerging market firms need technical expertise and financial capital to be competitive and their respective economies require these resources to develop and grow. Managerial expertise is important to firms entering an emerging economy, while it was a significant predictor of partner selection, it was less important than some other characteristics.

A focus on process is largely absent from the alliance literature [20]. However, in the context of changing environments with evolving industry practices and firms' strategies, a focus on process is especially important. After making the decision to engage in collaboration, the selection of an appropriate partner is the next critical decision. While some research exists on partner selection, (e.g. refrain from ‘cheating’ behaviour and taking sanction against transgressors) [21] more research is required. The results support resource based and organizational learning explanations of collaborator selection, with client entry to China needing Gammon Skanska to ‘leapfrog’ regulatory and culture issues.

4. Conclusions

Much of the collaboration experience is about learning and knowledge acquisition – this is described in the literature – noting that knowledge acquisition can control the balance of power between the parties especially where negotiation is via a tacit agreement rather than formalized contract, this is supported by the case studies where the intangibles of management process and procedure are crucial for the partnering success.

Collaboration is becoming a highly popular strategy among firms throughout the world. There are several explanations for the formation of strategic alliances; prominent among them is as a means of entering international markets. Emerging markets are characterized by considerable growth and volatility – providing a context high in ambiguity, risk, and change. As market economies continue to evolve, firms from emerging markets seek new ways to enhance their competitive positions – they differ from their developed market counterparts in terms of alliance objectives and partner selection criteria. Managerial capability is more important for developed market firms than for emerging market firms. Emerging markets need up-to-date technological capabilities to be efficient and to produce goods with sufficient quality in order to compete in domestic and global markets. Firms from emerging countries search for partners with technological and managerial capabilities; Western firms seek out alliance governance issues and accountability, which, in China, can be difficult to establish.

In China, firms need partners that help them develop the capacity to learn and then transfer the required knowledge. Thus, they search for partners with strong intangible assets; hence, partner reputation plays a major role in a collaborator selection. While intangible assets are important to all alliance partners, legitimacy is critical to firms from emerging markets, which develop alliances with partners to enhance their own reputation and image. Emerging market firms emphasize intangible assets in partner selection.

Resource-based theories and organizational learning provide prominent explanations for collaboration. Various arrangements of governance, resource management and control are associated with satisfactory performance but the fit between these factors, within an arrangement, particularly, impacts on the performance of the alliance. Compatibility is a key determinant of synergetic benefits.

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Comparative Survey of Clients between Japan and Korea

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Abstract

The client (owner) is the individual or organization that is the instigator/initiator and ultimate buyer and possessor of the project. By virtue of these roles, the owner is totally responsible for the financing of the project, prior to, during and subsequent to construction. The purpose of this study is to analyse the current state of the client, demand-supply system and project delivery methods between Japan and Korea. The construction industry of Japan takes up 14.6% of the GDP and employs about 6,320,000 people, which is almost 9.9% of the total national employees. The construction industry of Korea takes up 14.3% of the GDP and employs about 1,570,000 people, which is almost 7.4% of the total national employees. For this reason, construction industry is very important industry between two countries.

Following a literature review on background context, questionnaire was designed focused to seek more reliable information from two countries. The study has been performed by questionnaire of private sectors client. This study inquires into the extent of major differences between Japan and Korea in the perception of demand-supply system and of VE, CM. A five-page questionnaire with eight categories was distributed to about 3,983 (2,492 to Japanese clients, 1,491 to Korean clients) clients from June to September 2004.

Keywords: Client, Construction industry, Questionnaire, CM, VE, Japan, Korea

1. Introduction

The owner is the individual or organization that is the instigator/initiator and ultimate buyer and possessor of the project. By virtue of these roles, the owner is totally responsible for the financing of the project, prior to, during and subsequent to construction. It is also the person or firm who has identified the need that could be solved by a construction project. The owner is referred to as Client when involved in the hiring of and relationship with legal, design, construction management, constructor, and other professionals. The words client and client are often used interchangeably. Usually client is also applicable to the actual user of the project, such as the lessee or tenant of the single space in a shopping mall, or the owner/user/occupant of the isolated building or complex [1].

Although Japan and Korea are geographically close together, there have seldom been any interactions especially in construction industry due to their country systems. These two countries have much in common, extensive interchange will provide more benefits than ever expected.[2)] This paper details Japanese and Korean clients in terms of project conscious, contract system, VE proposal system and CM. In Japan, the bottom of the depression in which recent years are prolonged, construction industry shows the diversification and the complication accompanying excessive competition. In these circumstances, construction order system has been changing. In Korea, after the Korean economy crisis there was a movement of rethinking on the construction industry. The main issue was to find and develop how to enhance its industry structure in order to increase its cost-effectiveness. This research investigates the present condition of consciousness of a client in a construction project, grasping the degree of satisfaction to project and clarifying client's viewpoint between Japan and Korea.

2. Research Methodology

This research investigation collected data from a variety of listed companies that are by mailing in Japan and Korea. In the case of Japan, there are Tokyo Stock Exchange (TSE), Osaka Stock Exchange (OSE) listed companies. In the case of Korea, there are Korea Stock Exchange (KSE), KOSDAQ listed companies. The research included the following phases.

- Phase 1: Extensive literature review-Due to the nature and extent of this study, the literature review was identified as a critical component in this research. Pertinent literature was reviewed general information on construction industry of Japan and Korea, global and local competitiveness.

- Phase 2: Development of the questionnaire - The pilot questionnaire was designed Kano's study [3]. That is investigation in the Japan only.

- Phase 3: Data collection-The final questionnaire was sent to 3,982 companies during 2004. The number of completed questionnaire was 320, a response rate of 8.0% (8.7% in Japan, 7.0% in Korea)

- Phase 4: Coding and analysis of data-After the questionnaires were completed and returned they were entered into computer databases and analysed.

Table 1: Questionnaire (part).

A survey on construction project client

The outline of your company

Please mark O to the type of firm that describes your company best, and fill in the blanks.

(1) Type of firm

1. Agriculture/Forestry/Fisheries 2. Mining 3. Construction
4. Manufacturing 5. Wholesale/ retail trade 6. Finance / insurance
7. Real estate 8. Transportation/communication 9. Electricity/gas
10. Service 11. Others (______)

(2) Foundation year
(3) Capital 100 million yen
(4) Annual Sales 100 million yen
(5) Number of employee person

Department for a construction project

Please fill in your main department that takes charge of order and contract of construction work.

(1) Department name 1.name 2.not decided especially
(2) Number of employee in the department person

About the project for the last five years

(1) Please mark the type of considerable project for the last five years (multiple choice is possible)

1. Office 2. Factories 3. Shopping Mall 4. Hotel 5. Apartment
6. Others ( )

(2) Rough total construction amount-of-money (for the last five years):
100 million yen

(3) Fill in the main contract type for the last five years.

(A) Please mark O to the design and audit type.

1. Ordered to a same design firm for every project (if this is chosen, proceed to question B).
2. Ordered to a same design department in a construction company for every project (if this is chosen, proceed to question C).
3. Ordered to a design firm recommended by bank.
4. Ordered to a design firm recommended by construction company
5. Ordered to an associated design firm of your company.
6. It was not decided especially.
7. It is Unknown.

(B) This is the ONLY for the one who chose “ 1. Ordered to a same design firm for every project” in question (A). Please mark O to the less than three main reasons why it is ordered from a same design firm.

1. Solid integrity of the firm.
2. High reputation of the firm.
3. Strong design capability of the firm.
4. Solid construction supervision of the firm.
5. Since the client’s opinion is well reflected in the design of the firm.
6. Strong design capability of specific building design (Example: Factory, Office, Apartment, Etc.).
7. Since it has continued and ordered for a long time and cannot be changed easily.
8. Since it is associated company.
9. Others

(C) This is the ONLY for the one who chose “ 2. Ordered to a same design department in a construction company for every project ” in question (A). Please mark O to the less than three main reasons why it is ordered from a same design part of the same construction company.

1. Since it is easy to order design and construction altogether.
2. Since the department in the construction company is reliable.
3. Strong design capability of the firm.
4. Since the client’s opinion is well reflected in the design of the firm.
5. Strong design capability of specific building design (Example: Factory, Office, Apartment, Etc.).
6. Since it has continued and ordered for a long time and cannot be changed easily.
7. Since it is associated company
8. Others

(D) Please mark O for the way of selection for construction company.

1. Always same construction company.
2. A construction company is decided by estimation.
3. A construction company is decided by competitive bid.
4. A construction company is decided by bank recommends.
5. A construction company is decided by design firm recommends.
6. A construction company is decided by associated company.
7. It was not decided especially.
8. It is unknown.

(E) This is the ONLY for the one answered “1. Always same construction company ” in above question (D). Please mark O to the less than three main reasons the way of selection same construction company.

1. Solid integrity of the company.
2. High reputation of the company.
3. Since the cost of construction is the lowest.
4. Since the maintenance after completion is good.
5. Since there is a relationship with the business of your company.
6. Since there is a relationship with a correspondent bank of yours.
7. Since it has continued and ordered for a long time and cannot be changed easily.
8. Since it is an associated company.
9. Others

Table 2: Questionnaire Distributed/Responded Matrix.

Country	**Period**	**Distributed**	**Responded**	**Response rate**
Japan	2004.08.26-09.18	2,492	216	8.7%
Korea	2004.07.16-08.14	1,491	104	7.0%

Survey items are mainly the following contents.

1) Outline of a client: Type of firm, Foundation year, Capital, Annual Sales, Number of employee

2) About the construction project for the last five years: Building classification, Construction cost, Design and supervision type, Way of selection for construction company

3) About the latest construction project: Building classification, Design cost, Construction cost, Who take the charge of the plan or project, Size of the design firm, Size of the construction company, Opinion on the result of construction project

4) About the future construction project: Plan to subcontract of the project and desired subcontract, Order opinion on design and build

5) About the VE (Value Engineering) proposal system: Opinion about VE, Compensation for VE

6) About the CM (Construction Management) system: Opinion about CM system, Order organization on CM, Expected advantage of CM

3. Research Results

3.1 Outline of Client

It is as follows when the outline of the company, which replied to the questionnaire, is shown. In addition, the value of N of each figure is frequency, and other number is % scale. As shown in Figure 1, in the case of Japan, manufacturing firms are the most as 52.3%, wholesale/retail trade firms are 14.8%, service firms for 8.8%, finance/insurance firms are 6.5%. In the case of Korea, manufacturing firms are the most as 57.7%, subsequently finance/insurance firms are 15.4%, transportation/communication 6.7%, and electricity/gas firms are 3.8%. Figure 2 is the annual sales of firms. In the case of Japan, from 1,000 billion to 2,500 billion firms are the most as 20.4%, from 250 billion to 500 billion firms and from 500 billion to 1,000 billion firms are the second as 13.4%. In the case of Korea, less than 100 billion firms are the most as 37.5%, from 100 billion to 250 billion firms are the second as 24.0%, from 1,000 billion to 2,500 billion firms are the third as 11.5%.

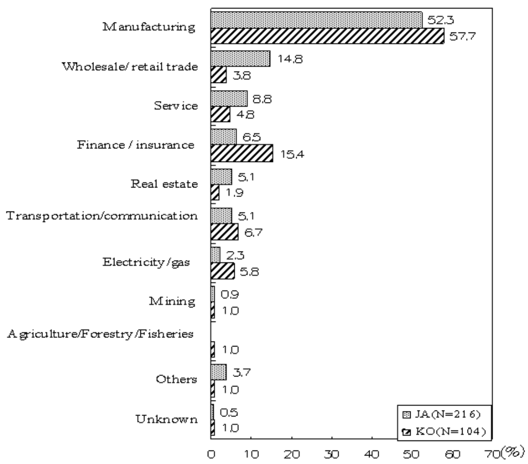


Figure 1: Type of firms.

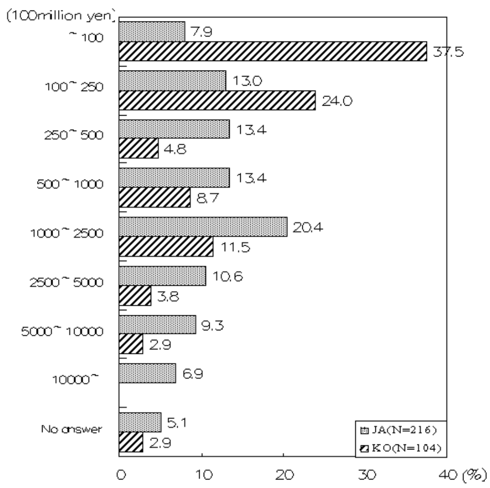


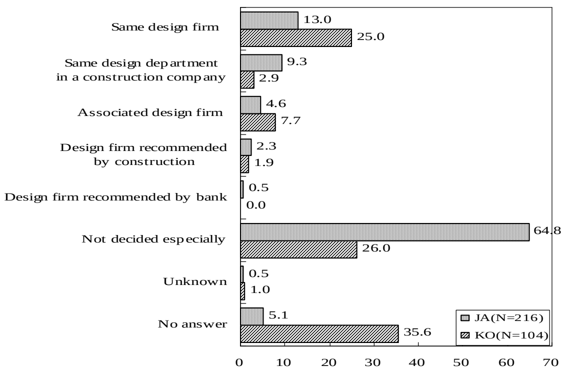
Figure 2: Annual sales (100 million yen).

3.2 About the construction projects for the last five years

This section describes the situation and the consciousness of the construction projects for the last five years.

3.2.1 Order type of the design and supervision

As shown in Figure 3, in the case of Japan, ordered to a same design firm for every project are the most as 13.0%, besides the answer for not decided especially. Ordered to a same design department in a construction company is the second as 9.3%. In the case of Korea, Ordered to a same design firm for every project are the most as 25.0%, besides the answer for not decided especially and no answer. Ordered to an associated design firm of the client company are the second as 7.7%. Ordered to a same design department in a construction company is the third as 2.9%.



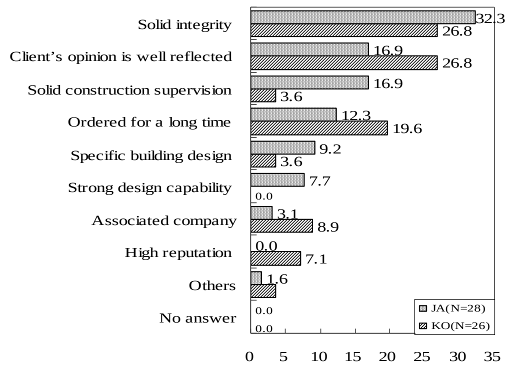


Figure 3: Order of he design and supervision. *Figure 4:Main reasons of same design firm.*

Figure 4 is main reasons why it is ordered from a same design firm. This is the answer for the client who chose "Ordered to a same design firm for every project" in above question. In the case of Japan, solid integrity of the firm is the most as 32.3%. Since the client's opinion is well reflected in the design of the firm and solid construction supervision of the firm is the second as 16.9%. Since it has continued and ordered for a long time and cannot be changed easily is the fourth as 12.3%. In the case of Korea, solid integrity of the firm and is since the client's opinion is well reflected in the design of the firm is the most as 26.8%. Since it has continued and ordered for a long time and cannot be changed easily is the third as 19.6%.

Judging from the above, the client of Japan and Korea wants to order not the strong design capability of specific building design, strong design capability of the firm but solid integrity, well reflected client's opinion. The client of Korea, they want to order by since it is associated company or high reputation of the firm than the client of Japan.

3.2.2 Way of Selection for Construction Company

As shown in Figure 5, in the case of Japan, select for construction company by estimation is the most, as 34.3%. Decided by competitive bid is the second as 24.1%. The third is the no especially decision on construction company as 23.1%.

In the case of Korea, select for construction company by competitive bid is the most as 22.1%. Decided by estimation is the second as 13.5%. The third is the no especially decision on construction company and always select by same construction company as 7.7%.

Therefore, it seems reasonable to conclude that estimation and competitive bid is popular way of selection for construction company in Japan and Korea. But it is quite likely that new way of selection will be spread in Japan and Korea.

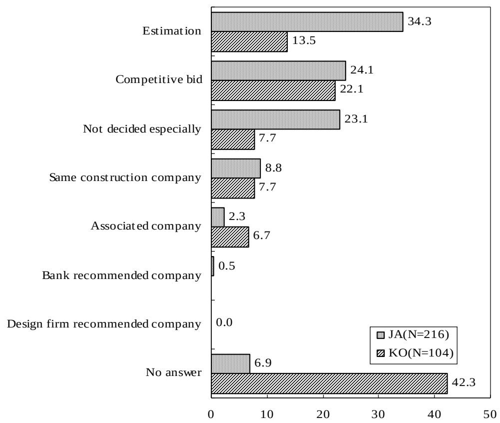


Figure 5: Way of selection for construction company.

3.3 About the Latest Construction Project

This section describes the situation and the consciousness of the construction projects for the latest construction project.

3.3.1 Building Classification and Construction Cost

As shown in Figure 6, in the case of Japan, factory project is the most as 35.2%. Office project is the second percentage as 25.0%. This is the same result of rank in the case of Korea.

Figure 7 is the result of construction cost. In the case of Japan, less than 1 billion project is the most as 52.8%. From 1 billion to 2.5 billion projects is the second percentage as 14.8%. In the case of Korea, from 1 billion to 2.5 billion projects is the most as 14.4%, besides no answer.

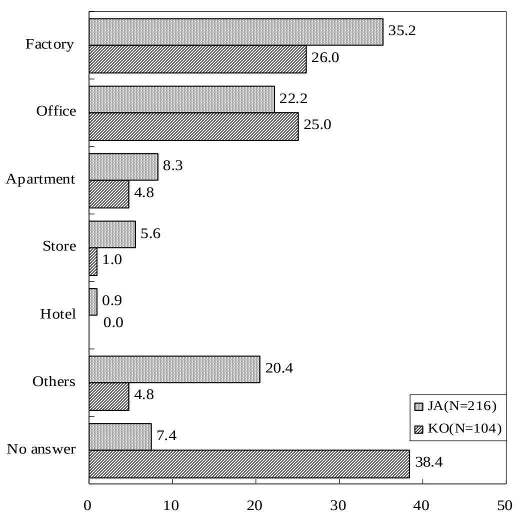


Figure 6: Building classification.

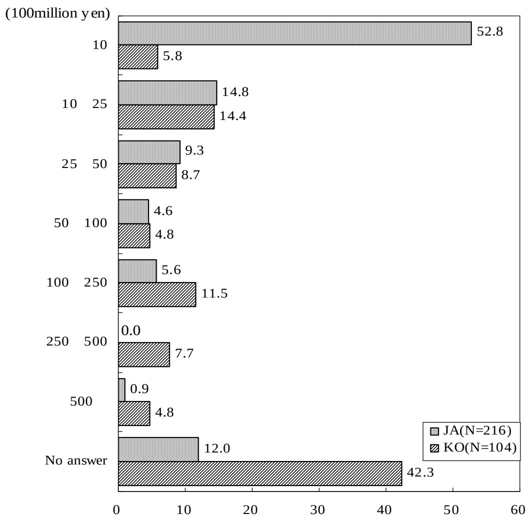


Figure 7: Construction cost of the latest project.

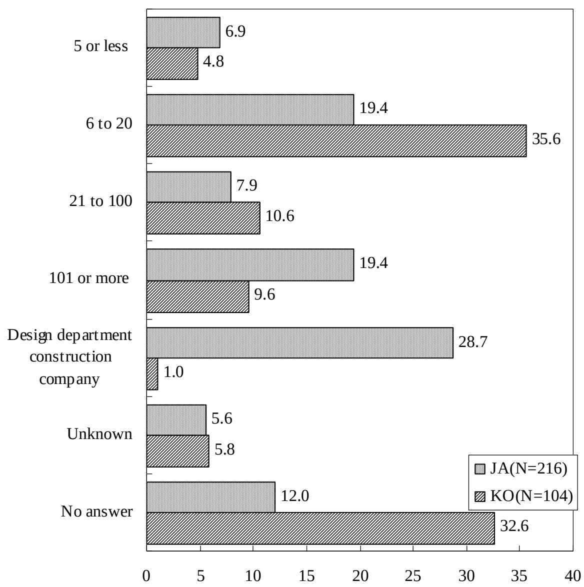
3.3.2 Size of the Design Firm and Construction Company Hired for the Project

As shown in Fig. 8, in the case of Japan, design department in construction company is the most as 28.7%.

6 to 20 personnel's design firm or 101 or more personnel's design firm is the second as 19.4%.

In the case of Korea, 6 to 20 personnel's design firm is the most as 35.6%. 21 to 100 personnel's design firm is the second as 10.6% besides no answer.

This result lead us to the conclusion that the hired design firm in Japan is differ from in Korea. In Korea, strong regulations restrict any market providers from easily getting into the market. Some organizations, which have multiple licenses, are not allowed to get into a certain type of market. For example, the General contractors are not allowed to get the Specialty contractor license or architect license. So, in the case of Korea, design department in construction company cannot receive of design order.



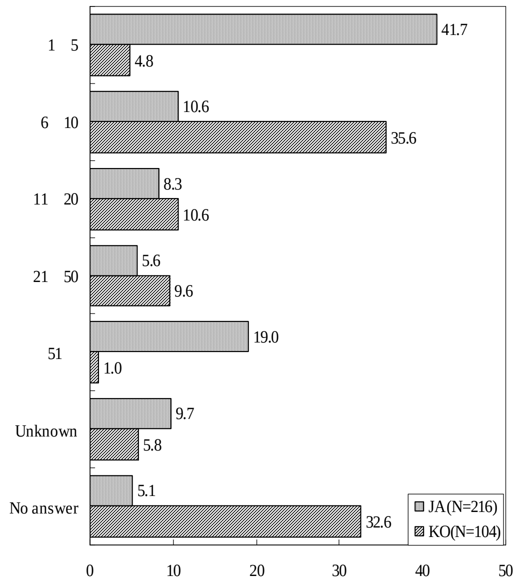


Figure 8: Size of the design firm.

Figure 9: Size of the construction company.

Figure 9 is the result of size of the construction company hired for the project. In the case of Japan, the 1st to 5th of ranking company is the most as 41.7%. Below the 51st of ranking is the second percentage as 19.0%. In the case of Korea, from 6th to 10th of ranking company is the most as 35.6%. From 11th to 20th of ranking company is the second percentage besides no answer.

3.3.3 Opinion on the Result of Construction Project

Figure 10 is the result of opinion for design firm about consideration of client after project.

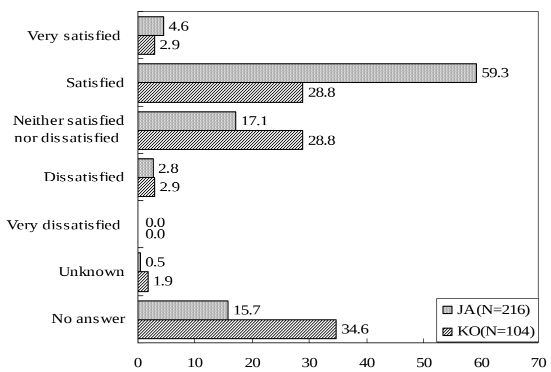


Figure 10: Consideration of the client opinion.

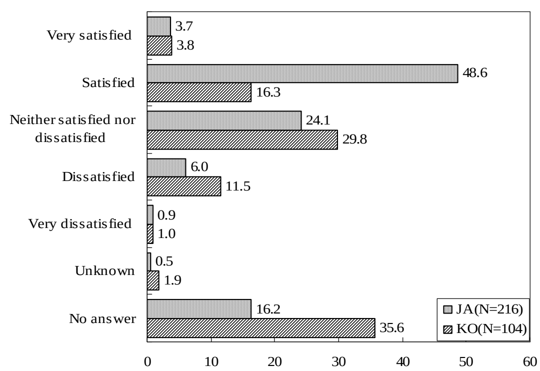


Figure11: Construction supervision.

In the case of Japan, “satisfied”is the most as 59.3%, “very satisfied”is the second as 4.6%. In the case of Korea, “satisfied”and “Neither satisfied nor dissatisfied”is the most as 28.8, besides no answer.

Figure 11 is the result of opinion for design firm about construction supervision. In the case of Japan, “satisfied”is the most as 48.6%, “Neither satisfied nor dissatisfied”is the second as 24.1%. In the case of Korea, “Neither satisfied nor dissatisfied”is the most as 24.1%, besides no answer.

From these results we can conclude that strict construction supervision by design firm is important factor to client opinion. Especially, Korean client appear dissatisfied attitude rather than Japan.

3.4 About the Future Construction Project

Figure 12 is the result of opinion on design and build type for future. In the case of Japan, “Want to order a design and build from a separate organization”is the most as 36.1%, “Whichever is sufficient “is the second as 30.6%. “Want to order a design and build from the same construction company”is the third as 27.3%.

In the case of Korea, “Want to order a design and build from a separate organization”is the most as 58.7%, “Whichever is sufficient “is the second as 20.2%.” Want to order a design and build from the same construction company”is the third as 15.4%.

From these results we can conclude that separate contract will be continue between Japan and Korea, but Japanese client want to contract the same construction company likely Figure 8 result.

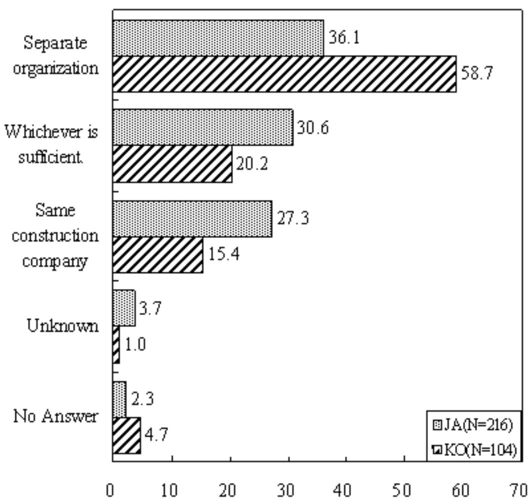


Figure 12: Design and Build contract.

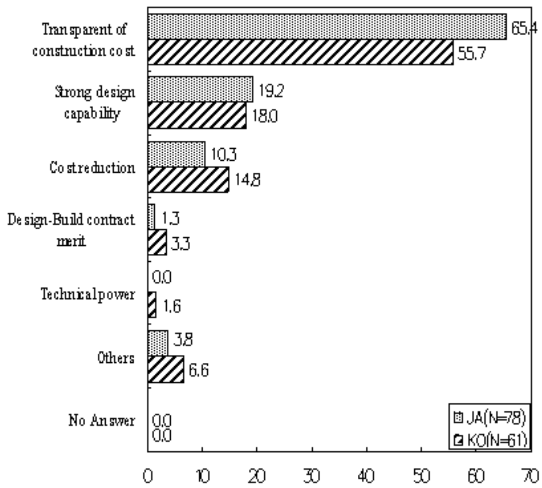


Figure13: Reasons of separate order.

Figure 13 is the reason why to order a design and build from a separate organization. In the case of Japan, “In order to attain transparent of construction cost “is the most as 65.4%, “Strong design capability of the design firm”is the second as 19.2%. “In order to plan cost reduction”is the third as 10.3%. These are the same ranking in the case of Korea. From these results we can conclude that client want to know cost information between Japan and Korea.

3.5 About the VE Proposal System

Value management is the name given to a service in which the sponsor of a project, the client, transmits a clear statement of the value requirements of that project to the project designers. Value management should not be seen as a conflict-oriented design review, cost reduction or standardization exercise. Maximum value as defined by Burt (1975) is obtained from a required level of quality as least cost, the highest level of quality for a given cost or from an optimum compromise between the two. Value management is therefore the management of the process to obtain maximum value on a scale determined by the client.[4)]

Figure13 is opinion about VE proposal system. In the case of Japan, “being utilized”is the most as 46.3%, “Want to utilize from now on”is the second as 16.3%. “It cannot be decided due to lots of unknown aspects of VE proposal system”is the fourth as 14.4%. In the case of Korea, “Want to utilize from now on”is the most as 54.8%, “It cannot be decided due to lots of unknown aspects of VE proposal system”is the second as 23.1%. “Want to utilize from now on”is the fourth as 6.7%. From these results we can conclude that VE proposal system in Japan is more popular than Korea. But many clients do not know VE proposal. Figure 14 is opinion about compensation for VE proposal. In the case of Japan, “Pay the expense concerning examination to VE proposal side”is the most as 25.9%, “Attribute all the amount of reduction to client”is the second as 23.1%. In the case of Korea, “unknown”is the most as 24.0%, “About 20% of the amount of reduction may pay to VE proposal side”is the second as 23.1%. From these results we can conclude that VE proposal system on Japanese client thinks as no charge service or include the expense among construction cost.

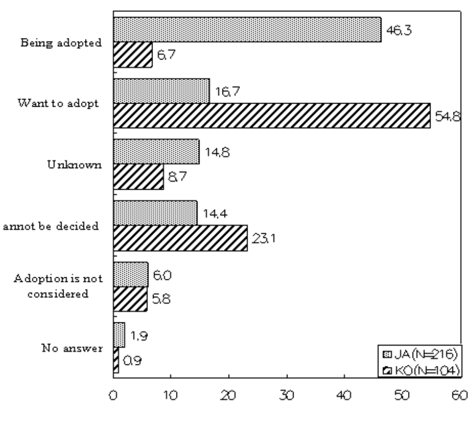


Figure 14:Opinions about VE.

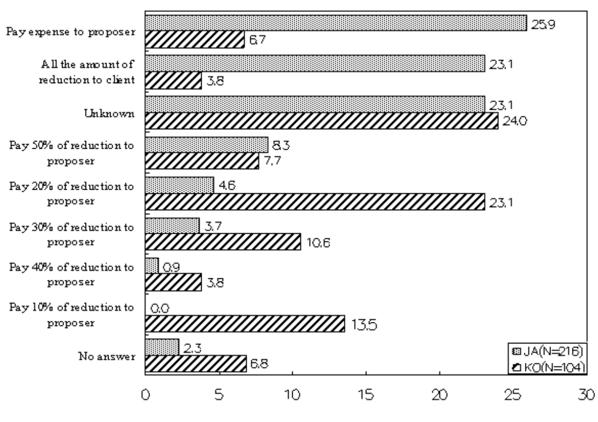


Figure15: Compensation for VE proposal.

3.6 About the CM System

Figure 16 is opinion about CM system. In the case of Japan, "CM system is considered for near future"is the most as 29.2%, "The current design-build contract system is satisfactory" is the second as 25.0%. "It cannot be decided due to lots of unknown aspects of CM system" is the third as 17.1%. "CM system is adopted" is the fifth as 9.7%. These are the same ranking on the case of Korea. But in the case of Korea "CM system is considered for near future"is higher than Japan.

Figure 17 is the results of order organizations on CM system. In the case of Japan, "As long as a reliable CM company offers CM service, CM can be considered as a future order form"is the most as 33.3%, "As long as a reliable design firm offers CM service, CM can be considered as a future order form"is the second as 32.3%. "As long as a reliable construction company offers CM service, CM can be considered as a future order form" is the third as 22.6%.In the case of Korea, they prefer CM company or construction company. This is the result of different start of CM service. In the case of Korea, in 1997 the ministry of construction and transportation proposed a scheme for enhancing efficiency and effectiveness of public-funded projects. One of the keywords in the scheme was the need for introducing CM system in the public sector. Laws and regulations needed for the CM adoption were enacted from 1999 to 2002 [5].

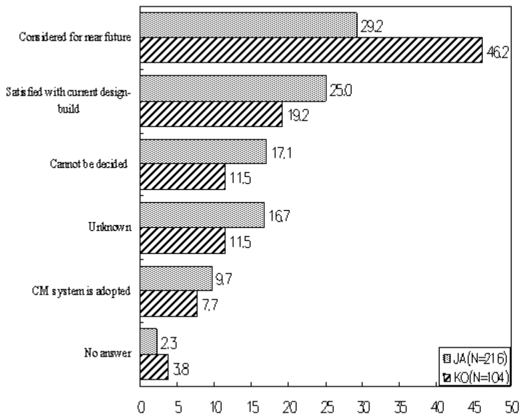


Figure 16:Opinion about CM.

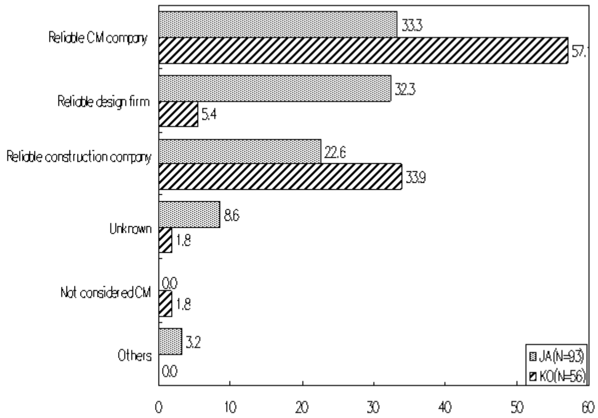


Figure17: order organizations on CM.

Figure 18 is the result of expected advantage of CM as compared with a lump-sum contract system. In the case of Japan, "Transparent of cost" is expect very much as 27.3%, "Cost reduction" is the second as 23.1%. "Improvement in quality" is the third as 13.9%. "Shortening of the time" is the fourth as 6.0%.

In the case of Korea, "Improvement in quality" is expect very much as 13.5%, "Cost reduction" is the second as 12.5%. "Transparent of cost" is the third as 11.5%. "Shortening of the time" is the fourth as 8.7%. From these results we can conclude that Korean client expect to improve in quality by CM system.

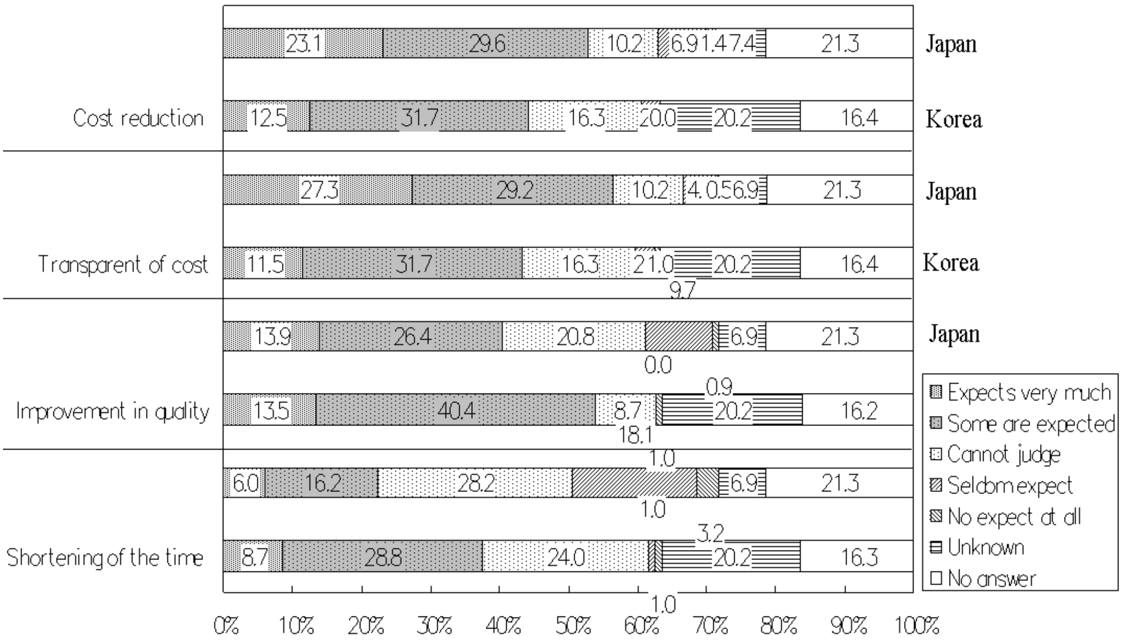


Figure 18: Expected advantage of CM.

4. Conclusions

The survey provided an opportunity to gather a broad range of information regarding the conscious of client between Japan and Korea. The insights provided by this survey should provide a basis for addressing the problems that may arise with order difficulty in Japan and Korea. We would like to state the following points.

1) Client of Japan and Korea wants to order not the strong design capability of specific building design, strong design capability of the firm but solid integrity, well-reflected client's opinion. The client of Korea, they want to order by since it is associated company or high reputation of the firm than the client of Japan.

2) Clients want to know cost information between Japan and Korea.

3) VE proposal system on Japanese client thinks as no charge service or include the expense among construction cost. Korean client expect to improve in quality by CM system.

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Consortia for Export of Construction Services in Singapore

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Abstract

After a period of continuous decline since 1998, the volume of demand for construction in 2003 was less than S$10 billion (US$1.00 = S$1.76), half the peak level in 1996. The progressive decline was precipitated by the Asian financial and economic crisis in 1997, and has persisted despite the recovery of the economy in Singapore. It is suggested that the level of activity will continue to be around S$15 billion in the medium term. Thus, the construction market in Singapore will not offer a sufficient volume of work for firms in the industry to grow. It has been suggested in several studies, and has been realised within the industry that firms must export their services to the region in order to thrive.

Singapore firms have been operating overseas since the 1970s. Their activities have tended to be within the South-East Asia region. Currently, China and India are considered to be countries which offer considerable potential volumes of activity. Singapore firms have different competitive advantages in each of these countries, and some firms have recorded significant successes. The literature highlights some pre-requisites for success in international construction. From these conceptual constructs, small and medium enterprises (SMEs) have no scope in this market. A major recent phenomenon in Singapore is the formation of both uni-disciplinary and multi-disciplinary consortia to seek, bid for, and undertake construction projects overseas.

This paper focuses on the SME consortia which are being formed in Singapore for international construction. It is based on a field study comprising interviews of senior practitioners and members of some consortia. The paper begins with a consideration of the literature on international construction and, in particular, the prerequisites for success and firms' strategies. It then presents the situation in Singapore. The results of the interviews are analysed and appropriate inferences drawn. Some appropriate actions for ensuring the formation of strong consortia and enhancing their performance on overseas projects are suggested.

Keywords: international construction, pre-requisites, competitiveness, consortium, corporate performance

1. Introduction

1.1 Aims and Objectives of Study

This paper reports on a research project on the appropriate strategies which can be adopted by Singapore construction enterprises to penetrate the market in South-east and East Asia which is expected to grow strongly in the medium-term future. The paper focuses on the small and medium-sized enterprises (SMEs), and considers, in particular the consortia which are being formed among such enterprises to export their services to countries in the South-east and East Asia regions. In Singapore, this is a new phenomenon as firms have, hitherto, tended to adopt a "go it alone" approach, resisting admonitions from government officials and researchers highlighting the merits of strategic alliances among the firms. Previous efforts among the local construction firms to form consortia, such as that of Mainland Construction, established by a group of contractors to explore the market in China in the early 1980s, have been very few, and the entities set up have been short-lived. Thus, it is pertinent to study the new phenomenon to assess the sustainability of the consortia and their potential to provide growth opportunities to the construction SMEs, especially in the international market.

The objectives of this study are to:

§ consider and evaluate the pre-requisites for success in international construction highlighted in the literature;

§ consider the need for Singapore construction firms to seek opportunities overseas;

§ discuss export strategies being adopted by Singapore construction firms, especially the SMEs; and

§ suggest initiatives for developing further, the export capability of the construction SMEs in Singapore.

1.2 Research Method

The study began with a review of the literature to identify the critical pre-requisites and success factors for international construction suggested by some of the key authors. Works on the historical performance of Singapore's construction firms in the South-east and East Asia regions were also reviewed. The review also covered the current situation within the Singapore construction industry in terms of demand and output. Some basic questions were then formulated to be used as a guide in structured interviews of senior construction practitioners in Singapore to obtain empirical information for the study.

The structured interviews were held with senior professionals and senior managers of construction and construction-related enterprises, including contractors, engineering and architectural design firms, quantity surveying firms, and financial institutions. Also interviewed were representatives of the professional institutions and trade associations, as well as officers of government agencies involved in the management of the development of the construction industry, and the promotion of exports. A list of the interview questions was sent to each of the interviewees before the interview was held.

The part of the study which this paper reports on relates to the consortia which have been formed among construction SMEs in Singapore for the export of construction services. The questions which this part of the study sought answers to were:

1. how and why the consortia were formed;

2. how the consortia operate, and the relationship among the members; and

3. possible future of the consortia, including their further development.

2. Export Performance and Local Output Levels

2.1 Export Performance

Singapore construction enterprises have exported their services since the 1970s, and have undertaken projects in Brunei, China, India, Indonesia, Malaysia, Myanmar, the Philippines, South Korea, Taiwan and Thailand. Some firms have worked further afield, in Australia, Libya, Mauritius, Mexico and Uganda. In recent years, the export drive has taken Singapore firms to Central and Western Asian countries such as Kazakhstan and the United Arab Emirates; as well as the Pacific, such as Fiji.

Table 1 shows that, since records on this business activity started in 1984, the total volume of projects secured overseas by Singapore construction firms has increased from S$118 million in 1984, reached a peak of S$1.6 billion in 1992, and declined to S$431 million in 1998 following the Asian financial and economic crisis which affected the countries in the region which had constituted the market for the firms. The construction export volume has grown strongly since 2001, reaching S$805 million in 2002 and S$1200 in 2003. The higher volume in 2003 is attributed to increased demand from Southeast Asia, India and the Middle East. The volume for 2004 is reported to have reached the S$2 billion mark.

Table 1: Export of construction services by Singapore contractors, selected years (S$million) [1].

Year	1984	1986	1988	1990	1992	1994	1995	1996	1998	2001	2002	2003
Export Volume	118	346	543	1069	1595	1170	1546	1338	431	787	805	1200

Key features of the overseas volume are that it is mainly in the form of buildings. In 2001, the export volume comprised: industrial buildings, 48.3%; commercial buildings, 34.2%; and infrastructure, 8.8%. A second feature is that most of the work is done by large firms [2]. In 2001, about 80% of the work was won by only three firms: United Engineers, SembCorp Engineers & Constructors, and Jurong Engineering [3].

In Singapore, the construction export drive has received greatest emphasis during periods of low domestic activity. The first concerted effort, led by the then Construction Industry Development Board (CIDB), which had been set up to spearhead the expansion and development of the industry, followed the economic recession in 1984 which precipitated a four-year decline in demand and output. The current emphasis on exports follows the low level of construction activity since the late 1990s, as discussed in the next section.

2.2 Levels of Activity in Singapore

Since the Asian economic and financial crisis in 1997, the output of Singapore's construction industry has been in decline, and predictions that the industry's decline has bottomed out have failed to be borne out. Table 2 compares the growth in construction GDP since 1998 with that of overall GDP, and shows that the industry has continued to decline as the economy has recovered and grown strongly [4]. Value added in construction fell every quarter between 1999 and 2003, and in some years (notably in 2002, the decline was in double-digit figures).

Table 2: GDP in Construction and its Growth Rate, 1998-2003 [3].

	1998	***1999***	***2000***	***2001***	***2002***	***2003***
GDP (1995 market prices) (S$m)	138,399	147,288	161,143	157,319	160,853	164,266
GDP Growth Rate (%)	-0.9	6.4	9.4	-2.4	2.2	
GDP in Construction (1995 market prices) (S$m)	12,325	11,217	11,009	10,657	9,503	8,635
GDP in Construction Growth Rate (%)	2.4	-9.0	-1.8	-3.2	-10.8	

The private sector of the construction market faces a glut in most types of property; and public sector demand has lost steam as many projects have been brought forward in a bid to provide opportunities for the industry (leading to an increase in demand of nearly 16 percent in the second quarter of 2002). Table 3 shows the distribution of demand ("contracts awarded") and output ("certified payments") from the public and private sectors. The data show that the two sectors accounted for nearly half of the total output each. The data indicate that, in most of the years during the period, the demand from the public sector was higher than the private sector. The massive decline in overall demand in 2003 resulted almost wholly from a decrease in the former.

Table 3: Building and Construction Activities, 1998-2003 (S$ million) [3].

	1998	**1999**	**2000**	**2001**	**2002**	**2003**
Contracts Awarded						
Total	16,637	13,096	20,163	13,801	14,340	9,956
Public	10,664	6,445	12,108	7,384	9,608	5,302
Private	5,973	6,652	8,055	6,417	4,732	4,654
Certified Payments						
Total	19,828	17,249	15,926	15,753	13,054	12,024
Public	10,172	9,954	8,443	8,725	6,937	6,865
Private	9,656	7,295	7,483	7,029	6,117	5,159

Predictions by various researchers indicate that, in the medium term, local construction enterprises cannot expect a sustainable level of demand in Singapore to enable them to survive, let alone grow. A direct result of the low levels of activity has been a spate of corporate failures which have claimed some of the better established firms. Thus, it has been suggested by many authors and observers that Singapore construction firms must seek opportunities overseas. For example, Mr Cedric Foo, Minister of State for National Development, noted [5]:

“Venturing overseas to develop an external wing will become a necessity for many in the industry in order to overcome the constraints of our small domestic market.”

One of the six strategic thrusts of the industry review exercise, “Construction 21”, was: “Developing an external wing” [6]. The Construction Working Group of the Economic Review Committee (ERC) [7] proposed that 15% of the construction volume (about S$2 billion) should be from exports in 5 years time (an ambitious target at the time because, as shown in Table 1, exports in the early 2000s was about S$800 million). The Construction Working Group of the ERC [8] recommended that Singapore’s construction industry should seek opportunities overseas, especially in China and India which had bright prospects. It identified the following factors facing the Singapore industry: (i) overcapacity of local construction resources in the face of declining demand; (ii) the need to upgrade the capabilities of local firms to compete effectively with their foreign counterparts; and (iii) size and financial constraints which confront construction firms as they attempt to venture abroad.

This stress on construction exports is part of a national policy to internationalise Singapore’s economy which started in the mid-1980s [9]. Like its counterparts elsewhere, Singapore’s construction industry has a pyramid structure [10]. The firms include large ones such as SembCorp Engineers & Constructors, the largest civil engineering and infrastructure group in South-East Asia, and a multiplicity of small firms. However, the call on firms to export their services has mainly been aimed at the larger ones which are expected to possess the required attributes. Thus, what are the options for the SMEs? It would appear that, if the overseas market is the only means by which Singapore construction firms can survive, then the SMEs must find viable means to gain the wherewithal to enter that market effectively and successfully.

3. Literature Review

3.1 3.1 International Construction

The pre-requisites for competition in international construction constitute effective entry barriers. The United Nations Centre for Transnational Corporations (UNCTC) [11] suggests that the most important barrier is technical knowledge. Linder [12] cited the following determinants of the success of European and US firms in the international market as access to: the most efficient means of production; cheapest and best building materials; and engineering knowledge. Constantino [13] categorised the “major competitiveness issues” in international construction into: human resources; management technology; government disincentives to invest; and technical capability. Managerial expertise was the most important among these owing to the peculiarities and problems of overseas projects.

The Market Analysis Task Force of the European Construction Institute [14] ranked the sources of competitive advantage in international construction as: project finance; reduced project timescales; technical expertise, experience and reputation; willingness to carry risks; ability to procure globally; management and re-use of information; political backing; corporate infrastructure; ability to provide project funding; ability to form partnerships or alliances with firms with skills in construction or other areas such as finance, design and operation; and ability to adopt company structures to work in multi-firm, multi-cultural and multi-discipline networks. The International Construction Task Force [15] advises companies to: identify compatible values and philosophy; sustain long-term relationships; take equity in projects; provide additional services; establish global partners and alliances; develop environmental responsiveness; develop new technologies; utilise information technology; and educate their personnel to work in a new client-contractor environment. Linder noted that the factors which contributed to the superiority of US contractors between the sixties and the mid-eighties included: their technological edge; their domestic track record on major projects; and special niches they could exploit.

Momaya and Selby [16] quantified the international competitiveness of the Canadian, Japanese and construction industries with a three-component model: (i) competitive assets – factor costs, human resources, industry infrastructure, technology, demand conditions, government; (ii) competitive processes – strategic management, formal planning, implementation, human resources development, R&D, synergies; and (iii) competitive performance – productivity, human resources, quality/effectiveness, cost, financial, international, technological. Low, et al. [17] highlight the following sources of competitiveness of UK firms on overseas projects: the extensive and competitive capacity of the UK financial sector; technical expertise and track record on large and complex projects worldwide; global strength of British consultancy firms; and historical political and diplomatic links. The determinants for Chinese firms which have become prominent abroad recently were: abundant supply of cheap and skilled labour; the high degree of motivation of the workers and their ability to work well in different environments; strong government support and financing flexibility; and historical links to developing countries.

Construction SMEs do not possess any of the competitive factors highlighted in this section; they have limited corporate sizes, resources including managerial expertise, and track records on major projects. Thus, the literature does not consider how such firms can export their services. For example, Janssen [18] notes that global competitiveness "outside of Europe" (p. 718) does not directly concern the typical SMEs.

3.2 Developing Export Capability in Singapore Construction

It has been recognised in many studies that concerted and systematic efforts must be made to develop the capability of Singapore construction firms to export their services. A study into the potential to develop world-class Singapore construction firms found the following success factors of international construction [19]: (1) marketing – ability to understand the culture of the host country; contacts within the host country; a unique business approach; (2) management – quality of management; ability to structure partnerships; focus on key niches; development of core strengths; (3) experience and technology – possession of, or access to, technology in key areas; and (4) financial ability – financial resources BOT type projects; capability in structuring financial packages. After reviewing the literature, the NUS and NTU [19] summarised the differences between the international construction contracting firms operating in Singapore which were undertaking the bulk of the large projects in the country and their local counterparts as: (i) corporate size; (ii) length of corporate history; and (iii) track record – volume, variety and geographical distribution of projects, as well as performance on these projects.

In Singapore, the literature previously urged construction SMEs to merge in order to create viable corporate entities which would be able to enter the international market (see, for example, The Economic Committee [20]. Recent works have paid some attention to the formation of consortia and other strategic alliances among such firms. In its recommendations under the export thrust of developing an external wing, the Construction 21 Steering Committee [21] urged the Construction Industry Joint Committee (CIJC) (the umbrella organisation for the construction industry's professional institutions and client and trade associations) to encourage companies to take proactive efforts, and form consortia, to venture abroad. Ofori [22] suggests that the CIJC can help to co-ordinate initiatives by its constituent organisations including: arranging for the sharing of overseas experiences by firms; encouraging the formation of consortia for overseas projects; and setting up co-operative business arrangements with overseas counterparts.

The vision of the Construction Working Group of the ERC [23] for the construction industry in Singapore is for it to develop into one that will encompass all aspects of the construction value chain, from design to maintenance. It envisaged a few global sized firms supported by a network of specialist companies. Among the three broad headings under which the Group made its recommendations was: "Increasing the economic pie by venturing overseas". The suggestions included: harnessing talent and expertise with the public sector; forming joint ventures between public and private enterprises; and offering export credit and credit insurance to local construction enterprises.

The Building and Construction Authority (BCA), Singapore's construction industry development agency, assists construction, property and real estate enterprises to export their services [24]. The mission of the BCA is "to develop an advanced and competitive construction industry", and its vision is: "A construction industry amongst the best in Asia". The export assistance activities of the BCA include:

§ providing information, mainly through the Export Digest, a portal containing information on potential investment opportunities overseas

§ offering various export development incentives directly, or providing information on possible sources of appropriate schemes

§ organising and leading trade mission trips, visits, conferences and exhibitions

§ providing firms with information on the overseas market including contact persons and project leads

- § promoting and supporting the formation of consortia by Singapore construction enterprises to undertake projects overseas.

International Enterprise Singapore (IE Singapore) is the country’s export development and promotion agency. It is actively involved in promoting the export of construction services [25]. The vision of IE Singapore is to be an expert agency in firm-level growth, market intelligence and internationalisation strategies. Its main functions are to provide market information, and assist firms to build up their business capabilities and find overseas partners. The support schemes offered by IE Singapore to firms in the economy as a whole, in particular, manufacturing, which are relevant to the construction consortia include:

- § iPartner is extended when at least four companies come together, to be used to employ a Business Development Manager to look after the group.

- § International Bidding Assistance Scheme, to cover up to half of the cost of bidding; purchasing tender documents; travelling to engage in discussions with clients; and engagement of consultants

- § International Consortium Assistance Scheme (ICAS) helps meet legal costs of consortium formation.

The BCA and IE Singapore collaborate in their provision of support for construction enterprises. For example, they organise joint missions. In summary, the export development assistance schemes do not directly subsidise the firms’ production costs, but help in the companies’ marketing efforts before they win projects overseas.

4. Field Study

A series of alliances have been formed to explore the regional construction market. These consortia bring together firms with different expertise to form strong groupings. They focus on exploiting a niche area wch Singapore has built up expertise in. They include the Airport Consortium and the Maritime Consortium which are based on Singapore’s acclaimed excellence in the planning, design and development or airports and harbours respectively. The Sindia Consortium focuses on housing, and has won the contract for the design a major township development project in Hyderabad. Sindia includes CESMA, a subsidiary of the corporatised arm of the national housing agency, HDB Corporation.

Some of the consortia have been among SMEs. These have been of two broad forms. The first type provides greater size among firms in the same segment of the industry such as the consortium formed by SEP Partnership, JGP Architecture and Singapore Garden City Pte Ltd. to undertake the mater planning of a township in the Cixi New Economic Development Zone, Ningo City, China [26]. The second type of consortium provides both size and depth of expertise. An example is the STA Consortium, discussed below. In the latter form, the SMEs are utilizing the “Total Singapore Capability” approach advocated by Ofori [27].

The leader and another prominent member of one of the construction SME consortia were among the interviewees. The results are now summarised.

4.1 Consortium’s History

One of the interviewees noted that Singapore has featured prominently in the news in India over the past few years because of the physical achievements of the country (including housing and infrastructure), the lack of corruption, and as one interviewee noted, “how we organise to make things happen,” for example, how the country and individual investors organise themselves to attract finance. The interviewees believed that the opportunities for Singapore firms in India can be seen in the common link of both countries to the British legal and administrative systems, and the large volume of unmet infrastructure needs – roads, water, and electricity – although its IT system is very good.

In July 2003, over 20 Singapore construction companies visited India in a mission organised by the BCA. After hearing many presentations of potential projects by Indian government officials and practitioners, some of the SMEs on the trip were interested in forming an alliance. After a series of meetings, the STA Consortium (STAC) was registered in Singapore as a limited private co-share partnership in September 2003 comprising 14 companies initially; the number of firms has increased to 16. STAC is dedicated to India; this is stated in its agreement. STAC members are not forbidden from joining other consortia. There are no written ground rules. The members have agreed to be transparent. The STAC was formed with the encouragement of the BCA, and with practical help under two government’s schemes: the Economic Grouping scheme of the Singapore Productivity and Innovation Agency (SPRING Singapore) and a grant from IE Singapore. Upon its formation, the STAC also applied for an iPartner grant of S$1million.

4.2 Mission and Operations

The mission of the STAC is: “Our consortium aims to offer our customers the best business practice and the highest ethical standards.” Members of the consortium provide the following services: master planning, township planning, park and streetscape design, architectural and engineering design and consultancy, project management, interior design, quality assurance consultancy, materials engineering and testing, geotechnical services, and materials and equipment supply.

The member companies come together in name under the STAC as a flag but each operates as a business organisation by itself. The interviewees perceived the STAC as a marketing tool to fly the Singapore brand name on behalf of the SMEs. The consortium comes in with its marketing track record. It is the point of contact by clients and potential business partners. Said one interviewee:

§ "STA Consortium is a flag you can carry with you if you are going to India as an SME. Because you will never be Sembawang, CPG, etc. [large enterprises]. It offers the members an opportunity. It also helps the Indian clients…."

However, they noted that the client must be confident in the individual company with which it transacts business. Members pay an agreed sum of money to support the secretariat and operations of the consortium. However, they keep whatever they earn. The members of the STAC providing architectural design services have been the busiest. They choose other project participants from the consortium, as and when they win commissions.

The members of the consortium are aware that they have something special. One interviewee noted:

§ "The vehicle for consortia is leadership as well as the fuel to drive the consortium, not committees. Some say the fuel is money… We need to get the government to understand that the SMEs are still capable. There is a gap of mindset between the SMEs and government but this is only a mindset."

At the time of the interviews, STAC was prospecting on 18 projects. Whereas there had been many in-principle agreements and memoranda of understanding, it was clear that the process of winning contracts was a long one.

Member companies of STAC pass on business contacts to other members. The interviewees noted that this has surprised observers (including officers of the BCA and IE Singapore which have encouraged such co-operation among local firms for several years) as Singapore firms are well known to be secretive and unwilling to share information. The members of the consortium are not relying on the opportunities it brings them, but are finding niches for themselves, as well as seeking to improve their capabilities to enhance their performance and competitiveness. Members of the consortium are aware of the challenges their firms face in the overseas market. One said:

§ "My staff are 10 times more expensive than those in China, and 20 times more expensive than those in Cambodia so if I do not make them run at least 20 times faster, I'm in trouble."

The company uses information technology and codifies documentation in order to improve the efficiency of his personnel.

4.3 Future Developments

The interviewees were open to the possibility of collaboration among some of the consortia. There are initiatives within the consortium to bring together smaller teams of the members. For example, one of the members of STAC, A.Alliance, an architectural firm, is forming the Alliance Business Unit where members can receive information free of charge until they win large projects. They will then start to pay a small fee. The interviewees also highlighted the scope for teaming up with firms outside the consortium, both large and small, including those in which the government has some ownership (called "government-linked companies" (GLCs) in Singapore). The interviewees noted that it would be good if the professional institutions and trade associations provide support to the consortia.

The interviewees also suggested that the government should be adventurous and entrepreneurial, and be willing to take risks. They noted that some projects require government involvement, and that the government should be keen to participate in what one interviewee referred to as "hybrid projects".

5. Conclusions and Recommendations

The construction consortia which have been formed among SMEs in Singapore are, perhaps, surprisingly to readers elsewhere, a new phenomenon in the country. However, some of these groupings have already undertaken some significant projects in China and India. Thus, they have successfully negotiated some of the pitfalls of international construction highlighted in the literature (see, for example, a long list of potential risks outlined by Wong et al. [28]). There is scope for the consortia to do even better. Continuous improvement and growth should be watchwords of the consortia.

The active support of the BCA in helping consortia to be formed, identifying opportunities and contacts for them and helping them to execute their projects has been decisive in their success. It would be appropriate for the BCA to seek ways by which it can continue to add value to the efforts of the consortia. Continued direct links between the BCA and the consortia, and structured feedback systems would help to achieve this.

The construction consortia or portions of them should explore opportunities at home to build up their track record; such groups would be most suitable for design and build projects which form a growing part of the market in Singapore. This would help them to learn together and improve their performance, as well as establish their experience and credibility. It would also enhance their ability to compete with their larger local and foreign counterparts. Moreover, firms which work together on design and build projects should consider forming establishing longer-term collaborative arrangements such as export-oriented consortia. At the broad level, the SME consortia can be blocks for building the construction industry in Singapore as an integrated entity.

The SME consortia have brought together firms with complementary expertise, but mainly among planning, design and contracting firms. There is scope for other firms in the construction value chain, such as suppliers and financial institutions, to join some of these consortia. Finally, the individual members of the consortia should take advantage of the government's development schemes for SMEs. It would also be good if appropriate schemes for partnerships similar to the consortia were formulated and offered.

Singapore enjoys a good reputation in the region for the quality of its township planning, building design, and construction workmanship. Efforts should be made to maintain and even enhance this reputation.

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Entering Regional Construction Markets in Russia

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Abstract

The entry opportunities of foreign firms are herein addressed concerning the five regional construction markets in Russia, i.e. the Moscow region, St. Petersburg region, Nizhjyi Novgorod region, Yekaterinburg region, and Rostow-au-Donau region. The theoretical basis for managing a firm's market entries is presented. The interview method and in particular the branch types, the organizational positions, and the level of expertise among the 44 interviewees are reported upon. Only the selected sub-results of these interviews are addressed as follows. The high, medium, and low market potentials are highlighted concerning the building construction, the building products supply, and the infrastructure construction in the five regions. The five entry environments are described in terms of the perceived success factors, the risk factors, and the entry modes. Finally, some promising ways of entering one of the five regional construction markets are suggested for foreign contractors, designers, and building products suppliers.

Keywords: Construction, entry strategy, international construction business, Russia

1. Introduction

The paper is based primarily on **the interview data** of the market research programme "International Competitiveness of the Finnish Construction Industry" that was financed by the National Agency of Technology in Finland (Tekes) and managed by the programme team within the Federation of Construction Industries in Finland (RT) during the year 2004. In turn, the TKK/CEM study team of the unit of Construction Economics and Management at the Helsinki University of Technology assumed the supporting roles of a data processor and a market analyst concerning the construction markets in Estonia, Hungary, Latvia, Lithuania, Poland, and Russia.

Herein, the focus is only on **the five regional construction markets in Russia**, i.e. the Moscow region, St. Petersburg region, Nizhjyi Novgorod region, Yekaterinburg region, and Rostow-au-Donau region. Obviously, these five regions are considered to belong to the ones which are likely to offer the most attractive entry opportunities for foreign construction-related firms.

Overall, **the aim** of this paper is to evaluate roughly the entry opportunities of foreign firms in the case of the five focal regions in Russia up to the year 2008. The sub-aims include (a) to present the selected theoretical basis for market entry management, (b) to report briefly on the interview method and the 44 interviewees, (c) to describe the market potentials and the entry environments based on the selected interview results, and (d) to suggest some promising ways of entering one of these regions for foreign construction-related firms in the near future.

No particular emphasis is given to Finland-based firms and their operations in Russia. Instead, the market development and entry opportunities in the case of the five focal regions in Russia are addressed from the view or foreign (preferably EU-based) construction-related firms.

2. Theoretical Approach to Entry Management

Herein, our approach to the management of a firm's entry into a new construction market is based only on one generic reference [1] and one construction-focused reference [2] as follows. In general, **an international market entry mode** is an institutional arrangement that makes possible the entry of a company's products, technology, human skills, management, or other resources into a foreign country. Entry modes are classified into exports, contractual, and investment modes. In **export entry modes**, a firm's final or intermediate product is manufactured outside the target country and subsequently transferred to it. **Contractual entry modes** are long-term non-equity associations between an international company and an entity in a foreign target country that involve the transfer of technology or human skills from the latter to the former. Contractual entry modes are primarily vehicles for the transfer of knowledge and skills, although they may also create export opportunities. **Investment entry modes** involve the ownership by an international firm of manufacturing plants or other production units in the target country. International firms frequently combine contractual entry modes with export or investment modes. In practice the entry strategy is iterative with many feedback loops and concurrent and additionally it is a continuing, open ended process and more; it is a comprehensive plan [1 pp. 23-24, 26-28].

In the context of construction markets, a contractor, a supplier or a designer, as an entrant, must face and penetrate en extremely "hard" wall surrounding the targeted competitive arena consisting of local clients, architects, contractors, and other stakeholders that are glued together with local contracting rules, building regulations, traditions, and practices. **An entry problem** can be formulated as "How will a firm succeed in entering a new competitive arena (segment) and win initial projects despite the hard wall?" This entry problem can be divided into the three sub-problems, namely, (a) With "what" (kind of offering and competences) to win pilot contracts? (b) What kind of (non-)localized capabilities are required in order to sell, win, and manage the first contracts, and (c) How to enter a new competitive arena through the hard wall [2]?

One of successful entry strategies can be visualized as "a spearhead" leading to **a definition of spearhead strategy** as a lean, product based, adapted, differentiated (when adding value), and focused marketing approach with emphasis on tailoring sales rationale to fit the perceptions of each potential "soft" client. Herein, a soft client has (initially) a positive attitude toward the newcomer(s) in question. The non-equity spearhead strategy consists of six elements, i.e. (1) choosing a competitive arena, (2) identifying the soft/hard potential clients (and influencers), (3) adapting an entrant's existing offering, (4) differentiating the company's approach towards potential clients, (5) localizing of an entrant's capabilities, and (6) tailoring an entrant's sales arguments. This dual approach involves both the market opportunity-driven and the offering-based aspects (applying [2]).

Along the temporal dimension, an entrant can realize a specific spearhead strategy within each targeted competitive arena through **the four steps:** (i) the ideation and the drafting of a specific spearhead strategy with an emphasis on ways of local collaboration and localization, (ii) the test marketing of an offering scope and its attributes as well as the contractual rationale, (iii) the trial tendering, and (iv) the sales and pilot contracts. An entrant should accumulate knowledge and experience at least over the first full economic cycle with high and low demand fluctuations in the competitive arena in question before any decisive trade-off decisions. These decisions may concern investments in a local construction, design, or manufacturing subsidiary (via a new establishment or an acquisition), collaboration agreements with local (and other foreign) stakeholders, and the recruitment of local (and foreign) key persons for both local ongoing operations and project-specific contracts [2].

3. Interview Method

The paper is related to **the market research programme** “International Competitiveness of the Finnish Construction Industry” that was financed by the National Agency of Technology in Finland (Tekes) and managed by the programme team within the Federation of Construction Industries in Finland (RT) during the year 2004. However, market development and opportunities are herein addressed in general from the foreign firms’ point of view.

The RT management team adopted the interview method in order to capture directly the relevant information from the stakeholders within the five converging construction arenas in Russia and, thus, to understand the market potentials and to perceive viable entry options. The original interview questionnaire was prepared both in Finnish and English. Concerning Russia, the RT management team assigned the interview task to an internal market-research firm with the local subsidiaries inside Russia. The firm translated the Russian version of the questionnaire. Its Russian interviewers carried out the interviews among the local experts in the five regions in Spring 2004. The Russian interview results were translated and re-written into **a set of the interview memorandums in English**. These memorandums form the primary empirical data, which the study team at the TKK/CEM processed, analyzed, and reported on internally to RT [3, 4, 5].

On the one hand, **the weakness** of this interview reporting lies in the fact that we, the data processors and the result producers, have neither designed the interview questionnaire, nor been involved in the face-to-face interviews. On the other hand, this fairly expensive overcoming of several language hurdles (from Finnish into English into Russian and back into English) is such a rare event in the field of international construction business research that **its explorative results** deserve to be reported on broadly to scholars (and practitioners). The paper is a presentation of deductions from the analysis of the interviews.

Thus, the reliability and the validity of the primary interviews are herein dealt with only indirectly. **The selection criteria of the interviewees** included the branch type, the organizational position, and the level of expertise. The fairly subjective branch distributions among the 44 interviewees appear in Table 1. The organizational positions and the levels of expertise as perceived by the interviewers and the attitudes of the interviewees concerning the interview are compiled in Table 2. Most of the interviewees were in the middle management positions with high expertise. The majority had a positive attitude towards the interview.

Table 1: Branch types of 44 interviewees within the five regions in Russia in Spring2004.

Branch types	Moscow	St. Petersburg	Nizhjyi Novgorod	Yekaterin-burg	Rostow-au-Donau	Total
Owner	0	0	0	1	0	**1**
Developer	1	3	1	1	2	**8**
Capital investor	6	0	2	0	0	**8**
Multi-business corporation	5	0	2	0	1	**8**
Designer (incl. CM)	1	0	0	0	0	**1**
Contractor (incl. CM)	0	1	3	2	0	**6**
Product supplier	4	4	1	1	0	**10**
Promoter of Finland	1	0	0	0	0	**1**
University	0	1	0	0	0	**1**
All Interviewees	**18**	**9**	**9**	**5**	**3**	**44**

Table 2: Three attributes of 44 interviewees within the five regions in Russia in Spring 2004, (a) organizational positions, (b) perceived level of expertise, and (c) attitudes concerning the interview questionnaire.

		Moscow	St. Petersburg	Nizhjyi Novgorod	Yekaterin-burg	Rostow-au-Donau	Total
a	**Top management**	4	4	2	3	1	**14**
	Middle management	12	5	6	2	2	**27**
	Key employee	2	0	1	0	0	**3**
b	**High expertise**	14	9	8	4	3	**38**
	Fairly high expertise	4	0	1	1	0	**6**
	Low expertise	0	0	0	0	0	**0**
c	**Positive attitude**	15	5	8	3	2	**33**
	Fairly positive attitude	2	4	1	2	1	**10**
	Negative attitude	1	0	0	0	0	**1**
	All Interviewees	**18**	**9**	**9**	**5**	**3**	**44**

4. Results of the Interviews

4.1 Market Potentials

One of the primary decision criteria for entering a new regional market involves the current level and the perceived future trend of the construction demand. Herein, the perceptions of 35 interviewees are compiled concerning the market potentials in the building construction, the building systems and products, and the infrastructure construction to the year 2008 on a scale of 10 (the highest potential) and 1 (no potential).

4.1.1 Market Potentials for Building Construction

The indicative perceptions of the market potentials in the building construction in the Moscow and St. Petersburg regions are illustrated only in part in Figure 1. Overall, the renovation of the building stocks is the only very high potential both in the Moscow and St. Petersburg regions. In addition, housing development is seen as the attractive segment in these two regions. The renovation is also seen as the high potential in the three NN-YEK-ROS regions. **In the Moscow region**, the only very high potential lies in the renovation of the building stocks. In addition, the three other segments are also seen as the fairly high potentials including the energy efficiency (new buildings and renovation of the old stock) and the own design-build construction of new residential buildings. **In the St. Petersburg region**, the three very high potentials are assigned to the prefabricated wooden family houses, the renovation of the building stocks, and the building design services. Instead, the industrialized building processes and prefabricated products are seen only as the fairly high potential. In addition, new office buildings are seen as the medium potential. **In the NN-YEK-ROS regions**, the very high potential is seen inherent in the renovation of the building stocks as well. In addition, new commercial buildings are seen as the high potential.

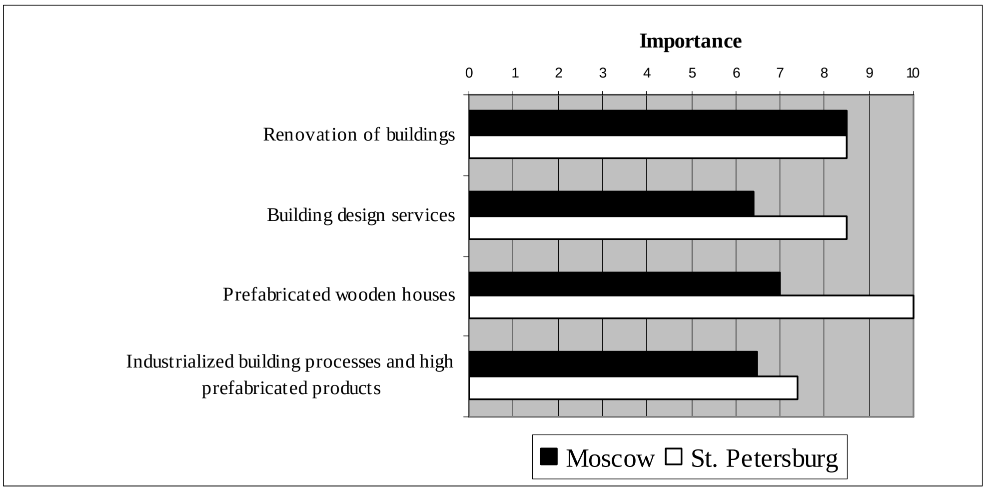

Figure 1: Market potentials for the building construction in the Moscow (m) and St. Petersburg (p) regions up to the year 2008 as perceived by the interviewees (n = 21 = 13m + 8p).

4.1.2 Market Potentials for Building Systems and Products

The perceived potentials of **the HEVAC and other building systems** appear in Figure 2a. Overall, all the building systems are seen as the high potentials across the five regions. Only steel-based (frame) structures are seen as the very high potential in the NN-YEK-ROS regions. Only the building automation systems are seen as the medium potential in the Moscow region. **In**

the Moscow region, the elevators are seen as the single high potential followed by steel-based (frame) structures and the HEVAC systems. **In the St. Petersburg region**, the two high potentials involve elevators and electrical systems. The other HEVAC systems and products are seen as the less high and medium potentials. **In the NN-YEK-ROS regions**, the steel-based structures and products have a very high potential. In addition, all the other systems, i.e. ventilation systems, heating and water systems, cooling and/or air conditioning systems are seen as the high potentials.

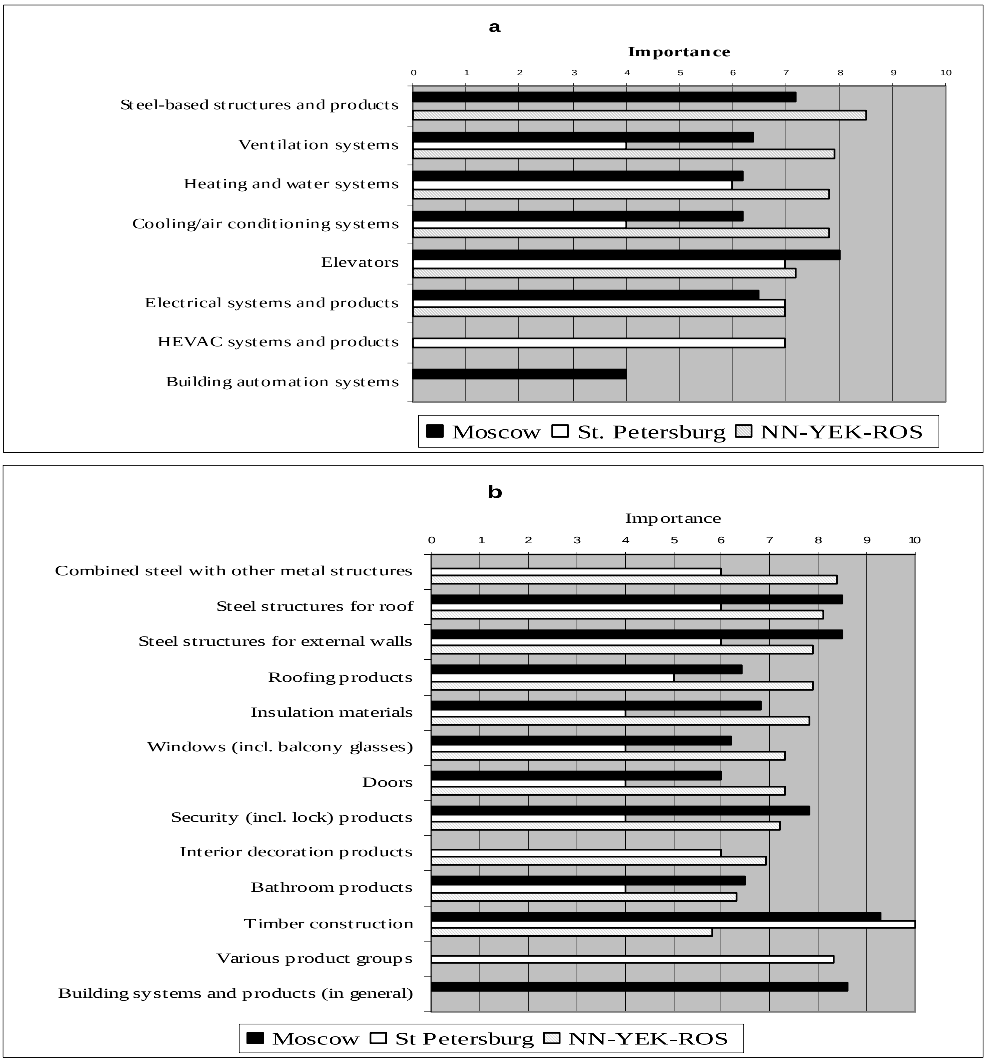

Figure 2: Market potentials for (a) HEVAC and other building systems and (b) building products in the Moscow (m), St. Petersburg (p), and NN-YEK-ROS (nyr) regions in Russia up to the year 2008 perceived by the interviewees (n= 35=13m+ 8p+14nyr).

The perceived potentials for **various building product groups** are compiled in Figure 2b. Overall, there are fairly big differences between the regional distributions. The (very) highest potential is seen in the use of timber both in the Moscow and St. Petersburg regions. The five building product groups are seen only as the medium potentials in St. Petersburg region. **In the Moscow region**, the very high potentials involve timber construction, steel structures for roof and external walls. The other product groups are also seen as the considerably high potentials. **In the St. Petersburg region**, the single very high potential is seen in timber construction. The four fairly high potentials involve the interior decoration products and the use of steel structures in roofs, external walls, and with other metal structures. Other roofing and insulation materials, windows, doors as well as security and bathroom products are seen as the medium potentials. **In the NN-YEK-ROS regions**, the five high potentials involve the use of steel structures in roofs and external walls as well as with other metal structures, roofing and insulation products. The three fairly high potentials are seen within windows, doors, and security products.

4.1.3 Market Potentials for Infrastructure Construction

Herein, the two main parts of the infrastructure construction are reported on as follows. The potentials of **the transportation systems** appear first in Figure 3a. Overall, the three distributions differ a lot. There are no joint very high potentials within all the regions. All the sectors are seen as the (very) high potentials except that the railway construction is seen as the low potential in the St. Petersburg region. **In the Moscow region**, the four sectors, i.e. roads, bridges, harbors, and railways are seen as the high potentials. **In the St. Petersburg region**, the roads and bridges are seen as the very high potential. Harbors are seen as the high potential and railways as the low potential. **In the NN-YEK-ROS regions**, the very high potentials involve roads and railways. The high potentials are seen in the remaining harbors and bridges.

In turn, the potentials of **the environmental and urban systems or sectors** are illustrated in Figure 3b. Overall, the three distributions differ. Most of the sectors are seen as the very high potentials in the Moscow and St. Petersburg regions. Instead, the majority is seen as the high potentials in the three NN-YEK-ROS regions. **In the Moscow region**, the six sectors, i.e. landfills, toxic waste disposal, clearance of polluted land, water supply, waste water handling, and district heating are seen as the very high potentials. **In the St. Petersburg region**, these sectors and energy supply are seen as the very high potentials except that water supply is seen as the high one and district heating as the medium one. **In the NN-YEK-ROS regions**, the environmental and urban sectors are in general considered as the very high potential. The six sectors are seen as the high potentials and district heating is alone seen as the medium one.

4.2 Entry Environment

Entering one of the regional construction markets in Russia involves management of uncertainty. The poles of regional business, opportunities and risks, need to be captured before any decision is made. Herein, **the entry environments** are described in terms of the success elements, risk factors, and entry modes for foreign suppliers, contractors, and designers.

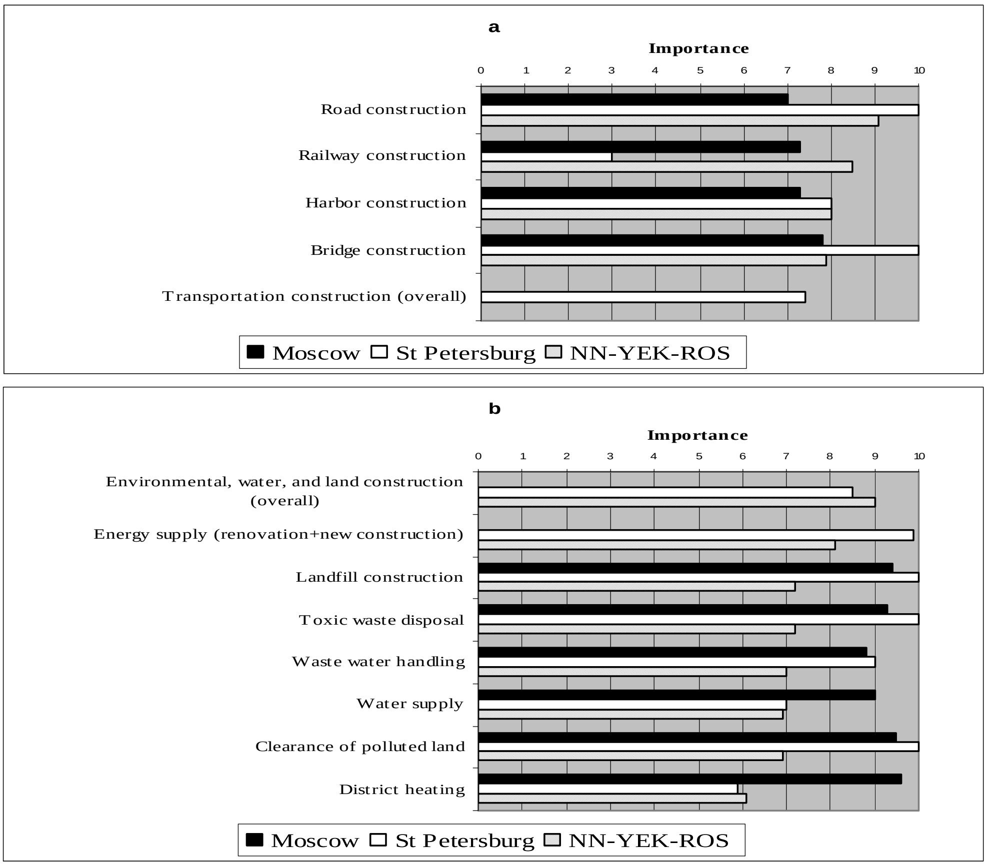

Figure 3: Market potentials of the infrastructure construction for (a) transportation systems and (b) environmental and urban systems in the Moscow (m), St. Petersburg(p), and NN-YEK-ROS (nyr) regions to the year 2008 as perceived by the interviewees (n=35= 13m + 8p+14nyr).

4.2.1 Success Elements

The prioritization of **the elements influencing the success of foreign firms** in the five regional construction markets in Russia appears in Table 3. Overall, nationality (11/26), references (9/26), and the stage of establishment (7/26) are perceived as the most common success elements. In addition, the other four given elements, i.e. local relationships (6/26), familiarity with local conditions (5/26), cooperation forms for construction (4/26), and negotiation ability (4/26) are also influencing the entry (and the penetration). The attitudes towards foreign actors are positive in all the five regions provided that the local stakeholders will also benefit from the entrants' offerings and operations.

In the Moscow region, nationality (6/12) is preferred. The interviewees also elaborated the top two nationalities, Finland (8/18) and Germany (6/18). In addition, references (5/12) and cooperation forms for construction (4/12) are mentioned. **In the St. Petersburg region**, nationality is not addressed at all among the success elements. This may be due to the Finland-focused bias in the interviews, i.e. the interviewees rank Finland (8/9) as the most preferred nationality followed by several countries (with only 1-2/9 nominations). Instead, the interviewees emphasize negotiation ability (4/7), the minimum stage of local establishment (3/7), and local relationships (2/7). **In the NN-YEK-ROS regions**, nationality (5/7), references (4/7), and local relationships (3/7) are preferred. In Nizhjyi Novgorod (NN), the interviewees rank Germany (6/9) and Finland (3/9) as the two preferred nationalities. In Yekaterinburg (YEK), Germany (4/5) and Finland (3/5) are ranked as well. In Rostow-au-Donau (ROS), Germany (2/3) and Italy (2/3) are ranked.

Table 3: Elements influencing the success of foreign firms in the Moscow (m), St. Petersburg (p) and the three NN-YEK-ROS (nyr) regions in Russia as perceived by the interviewees (n = 26 = 12m + 7p + 7nyr). Key: Numbers inside the boxes refer to the numbers of those inter-viewees who mentioned the element in question.

Success elements	Total	Moscow	St. Petersburg	NN-YEK-ROS
Nationality	11	6	0	5
References	9	5	0	4
Stage of establishment	7	3	3	1
Relationships with local people	6	1	2	3
Familiarity with local conditions	5	2	1	2
Cooperation form for construction	4	4	0	0
Negotiation ability	4	0	4	0

4.2.2 Risk Factors

The significant risk factors for foreign firms in the Russian regions are arranged in the order of frequency in Table 4. Overall, **the bureaucratic barriers** are the most important risk factor group including taxation, legislation as well as customs and licensing policies across all the five regions (20/41). The political situation in Russia is perceived as the second risk (9/41), followed by the legislative changes in State Duma (7/41). In addition, 2-5 interviewees emphasize, in turn, 11 other risk factors. The interviewees perceive **a broad risk profile in the Moscow region** (13/14 factors), the versatile ones in the Nizhjyi Novgorod (10/14), St. Petersburg (9/14), and Yekaterinburg (9/14) regions. Instead, only the three factors are emphasized in the Rostow-au-Donau region. In addition, the interviewees in the Moscow, St. Petersburg, and Rostow-au-Donau regions anticipate changes in the current risk profiles. In the Moscow region, emerging new risks include intergovernmental relations and the high fluctuation of personnel. In the St. Petersburg region, a new risk involves higher accommo-dation prices and land prices.

Finally, some interviewees address **the ways of mastering the region-specific risks** such as legal protection (counseling), project checking, regional business strategy, the recruitment of local qualified personnel, high technology and equipment, market research, and the establishment of offshore companies for ownership and tax-related reasons.

Table 4: Significant risk factors for foreign firms in the Moscow (m), St. Petersburg (p), and the three NN (n)-YEK(y)-ROS (r) regions in Russia as perceived by the interviewees (n=41=17m+ 8p+9n+5y+2r). Key: Numbers inside the boxes refer to the numbers of those interviewees who mentioned the factor in question.

Regions	Taxation legislation, customs and licensing policies	Political Situation	Legislative Changes in State Duma	Economic Situation	Instable Rate Exchanges	Lack of market knowledge	Investment Risks	Policy of Administration	Competitiveness	Uncertain partners	Timing of Payment	Finacial and Bank regulations	Instability in Construction Market	Natural cataclysm + Force Majeure
Moscow	8	3	2	2	3	2	3	2	1	1	2	1	o	1
St. Petersburg	5	1	2	1	1	1	0	1	1	0	0	0	1	0
NN	4	2	1	1	0	1	0	1	0	2	1	2	0	1
YEK	1	2	2	0	1	1	1	0	2	1	0	0	1	0
ROS	2	1	0	1	0	0	0	0	0	0	0	0	0	0
Total	**20**	**9**	**7**	**5**	**5**	**5**	**4**	**4**	**4**	**4**	**3**	**3**	**2**	**2**

4.2.3 Entry Modes

The most suitable entry modes for foreign building products suppliers, contractors, and designers in the five regional construction markets in Russia are summarized in Table 5. Overall, the interviewees recommended that a foreign company would enter through a local agency (24/42), the establishment of a fully-owned local subsidiary (18/42), project exports (13/42), and/or the establishment (or the acquisition) of a 50/50 joint venture (13/42). In product supply, the primary mode involves an entry through a local agency (13/42) coupled with exports (7/42). In contracting, the primary entry mode involves also a local agency (11/42) coupled with project exports (7/42). In design, the two primary entry modes are the establishment of a fully-owned subsidiary (7/42) and design services exports (6/42).

In the Moscow region, some interviewees (3-6/18) recommend each of the seven entry modes. In product supply, partnerships without ownership (5/18) are put forth only in this region. In addition, some interviewees stress the use of a local agency (5/18), deliveries as part of project exports (4/18), and direct products/materials exports (3/18). In contracting, the preferred entry modes include a local agency (3/18), project exports (3/18), and a fully-owned subsidiary (2/18). In design, the first design service contracts can be won as part of project exports (3/18) and/or through a fully-owned subsidiary (2/18). **In the St. Petersburg region**, most of the interviewees recommend an entry through a local agency (7/9) or the establishment (or the acquisition) of a 50/50 joint venture (6/9). In product supply, many interviewees stress the use of a local agency

(3/9) and direct products/materials exports (2/9). In contracting, the preferred entry modes include a local agency (4/9), a 50/50 joint venture (3/9), or project exports (2/9). In design, the primary entry modes are a 50/50 joint venture (3/9) or a fully-owned subsidiary (2/9). **In the NN-YEK-ROS regions**, the majority of the interviewees recommend an entry through a local agency (9/15) or the establishment of a fully-owned subsidiary (9/15). In product supply, some interviewees stress the use of a local agency (5/15), deliveries as part of project exports (4/15), and a fully-owned production subsidiary (3/15). In contracting, the preferred entry modes include a local agency (4/15), a fully-owned subsidiary (3/15), and project exports (2/15). In design, the primary entry modes include a fully-owned subsidiary (3/15) and selling design services as part of project exports (2/15).

Table 5: Most suitable operations for foreign (a) product suppliers, (b) contractors, and (c) designers in theMoscow (m), St. Petersburg (p), and the three NN-YEK-ROS (nyr) regions in Russia as perceived by the interviewees (n= 42=18m+9p+15nyr). Key: Numbers inside the boxes refer to the numbers of the interviewees who prioritize the entry mode in question.

Entry modes	Total	Moscow	St. Petersburg	NN-YEK-ROS	Moscow	St. Petersburg	NN-YEK-ROS	Moscow	St. Petersburg	NN-YEK-ROS
Through a local agency	24	5	3	5	3	4	4	0	0	0
100 % local company	18	1	1	3	2	1	3	2	2	3
Project exports	13	0	0	0	3	2	2	3	1	2
50/50 partnership company	13	2	0	1	1	3	1	1	3	1
As part of project exports	8	4	0	4	0	0	0	0	0	0
Materials/products exports	7	3	2	2	0	0	0	0	0	0
Partnership without ownership	5	5	0	0	0	0	0	0	0	0
Business/sector		Product supply business			Contracting business			Design business		

5. Conclusions

In this paper, the entry possibilities of foreign construction-related firms into the five regional construction markets in Russia are explored based on the interviews. Admittedly, the choices and the interviewing of each of 44 regional experts are based on the fairly subjective, local procedures. Nevertheless, it is concluded herein that **some promising ways of entering** one (or several) of these regions do exist for foreign firms in the near future as follows:

(1) Several very high market potentials are inherent in **the infrastructure construction** within all the five regions up to the year 2008. Most of the transportation sectors are seen as the (very) high potentials. Most of the environmental and urban sectors are seen as the very high potentials both in the Moscow and St. Petersburg regions. Instead, the majority is seen as the high potentials in the three NN-YEK-ROS regions. In **the building construction**, the renovation of the building stocks is the only very high potential both in the Moscow and St. Petersburg regions. In addition, housing development is seen as the attractive segment in these two regions. The renovation is also seen as the high potential in the three NN-YEK-ROS regions. In **the building products supply**, the building systems are seen as the high potentials across the five regions. The highest potential is seen in the use of timber in its various forms both in the Moscow and St. Petersburg regions. At the other end, many product groups are seen only as the medium potentials in St. Petersburg region.

(2) In order **to succeed in the targeted entry environment**, an entrant needs to become familiar with local conditions, engage in relationships with local people, and choose the proper stage of establishment. **These success factors** enable the entrant to deal with "hard walls" that surround each competitive arena as well as learn and manage **entry risks** such as bureaucratic barriers, political situation, and legislative changes that are likely to cause fluctuations across the five regions. **The viable entry modes** include a local agency, a fully-owned local subsidiary, project exports, and/or a 50/50 joint venture. In product supply, the use of a local agency is coupled with exports. In contracting, a local agency is coupled with project exports. In design, a fully-owned subsidiary and/or design services exports are recommended.

Finally, the five targeted regions were given based on the interests of the Finnish construction industry. Thus, there are **many additional regions** in Russia with very high market potentials (e.g. regions with rich oil and gas reserves) which deserve to be taken into account when foreign construction-related firms ponder which region(s) to enter in the short and longer term.

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Trust as a Success Factor in International Joint Ventures

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Abstract

International joint ventures (IJVs) in construction often face a highly complex environment, since in most instances they are formed to build large scale engineering projects. One of the primary requirements of actors in such systems is to reduce the environmental complexity. On an organizational level, many IJVs disentangle therefore responsibilities by functional separation and delegation of work. On a social level, delegation of work requires trust in the capability and willingness of others to perform their duties without supervision. As such, trust is a mechanism which allows us to reach our goals efficiently within this setting. Trust itself is mediated by communication involving symbolic interaction. Especially during the start phase, IJVs in construction are high-pressure environments without established networks. The intent of this article is to describe the research carried out and the conclusions drawn to determine the role of trust under such conditions.

Keywords: International joint ventures, construction, complexity, trust, culture, system theory

1. Trust as a Social Mechanism

1.1 Introduction

Traffic can be analyzed as a complex system constituted of millions of different subsystems. One such subsystem is defined by all those thousands of traffic participants with whom one car driver is involved over a given period of time. It has very specific rules which the participants learn when obtaining a driver's licence. Signs and signals communicate these rules for specific instances, e.g. a stop sign tells us to bring the car to a complete hold. Each participant plays a defined role in this system: as a driver, a pedestrian, a bicyclist or maybe as a policeman. The efficiency of this system, the ease of traffic flow, however, is not guaranteed by rules and roles. Only because we trust the other driver to halt at a stop sign we can pass through a crossing without reducing the speed.

Trust is central in many human relationships, be it on a personal (dyadic) or societal level. In the past decade a multitude of contributions has been published describing trust in different settings [1, 2, 3]. Trust develops differently in various contexts and the roles and functions it plays differ as well. Accordingly there are also different appropriate research methods. In this article, we will describe the phenomenon of trust as it appears in IJVs of the construction industry using grounded theory as research approach.

1.2 Approaches towards Trust

1.2.1 Trust as a Rational Choice

According to this line of thought, actors behave in a rational way to maximize their gains. Two of the most influential theories are transaction cost economics and game theory.

In transaction cost economics, two basic assumptions characterize actors: Human beings have a bounded rationality and they tend to behave in an opportunistic manner (self-interest seeking with guile). Moreover, the costs for any one transaction are the sum of production and transaction costs. Transaction costs arise ex-ante (information gathering, negotiation, contract) and ex-post (supervision, conflict solution and re-negotiation). Under these conditions, institutions should be organized taking bounded rationality into account and safeguarding against opportunism [4]. Trust plays no role, mistrust does. Williamson maintains that trust "…is warranted only for very special personal relations that would be seriously degraded if a calculative orientation were "permitted". Commercial relations do not qualify." [5]

The prisoner's dilemma is a well-known example illustrating the approach of game theory [6]. Two men are charged with armed burglary. There is only scant evidence, so that the prosecution depends on the statements of the two prisoners. If both confess the burglary, they will have to serve each five years in prison. Should both remain mute, they will be charged with one year each. If only one confesses, he will go free and the other one will have to serve a 20 year term.

Table 1: Payoff table for the prisoner's dilemma

		Burglar B			
		Confess		Remain mute	
Burglar A	Confess	A: 5	B: 5	A: 0	B: 20
	Remain mute	A: 20	B: 0	A: 1	B: 1

When both are questioned without the possibility to communicate, then the dominant strategy for both prisoners is to confess and they both will end up in jail for five years. Prisoner A does in this case not know, how B will behave and he will look at the two possible options: If B confesses, then B is better off also confessing (5 instead of 20 years). If B remains mute, confession brings A a better payoff (free instead of one year in prison). Since the strategies are the same for both prisoners, both will confess and serve five year terms if rationality prevails. The result is clearly not optimal. For reaching the best possible mutual solution by remaining mute, the prisoners would have to trust each other. In terms of game theory: Under conditions as above, a cooperative strategy is the best solution. Circumstances in which cooperative strategies evolve are a especially dependent on the pattern of payoffs and the "shadow of the future" [7].

Payoffs can be such that cooperation is encouraged and repeated games (shadow of the future) also bring about this result.

Criticism to the rational choice approach contents that people do not always engage in conscious calculations nor do they have an orderly set of preferences [8].

1.2.2 Trust as a Sociological and Cultural Phenomenon

Sociologists have been interested in trust for a long time. A rather comprehensive early study of the topic within a framework of functional-structural system theory was published by Luhmann in 1968 [9].[1] While Parsons [10] stresses the structural component in his normative system theory, Luhmann is more concerned with function [11]. He explains: “Trust in the broadest sense of confidence in one’s own expectations is an elementary fact of social life. Man has admittedly in many situations a choice whether or not to put his trust forward in a certain way. Without any trust, however, he could not leave his bed in the morning” [9]. The same conclusion can be drawn from the introductory example of a traffic system.

According to Parsons, we can only put our trust in people who share the same goals and values. It is the …” ‘feeling’ of the solidarity of collective groups” [12]. This excludes trust between different cultural groups who do not share the same values. Luhmann’s focus is quite different as he sees trust on the backdrop of his system theory. According to him, the central characteristic of modern societies is their overwhelming complexity. Complexity describes the multi-layered structure of society, where many levels operate interdependent on each other. This leads to the fact that each individual has many more options of experiences and actions then he can realize. Therefore reduction of complexity is the main task of modern societies. By constituting systems, such as an IJV with a specific task, we reduce complexity by creating a higher degree of order. Yet the internal complexity of such a system is still not manageable. One further mechanism of complexity reduction is trust. When trusting, we reduce the future complexity, because we choose to consider only a subset of all possibilities, e.g. that a colleague will solve a task satisfactorily in an IJV. As long as we trust in this, we rule out failure and act as if only a positive outcome is possible [9, 13].

Weber sees culture as an autonomous producer of social structure and networks. Both are structured through social action and thus culture is a cognitive category. Elements of culture can be material (artifacts) or immaterial (values, norms, symbols, language, knowledge). Culture is meaning-making in everyday life. The cultural world is that part of the universe which makes sense to humans [14]. Different societies or groups within one society can be described by their respective cultures.

On this cultural level, Fukuyama discerns societies with a low level of general trust from such with a high level. While diagnosing the need for future economic success, he asserts that

[1] In the English literature most often cited is the translation of two of his books “Vertrauen” und “Macht” as Luhmann, N. (1979). Trust and Power. New York: Wiley. The citations in this paper are based on the German original.

globalization will require flexible, large-scale business organizations, which can only develop in high-trust societies, such as Japan, Germany and the USA. For him trust is bound to the cultural system of meanings and indispensable for economic success in the future [15].

It should be clear that system theory offers poor explanations when researching trust in simple settings, since complexity is one of its axioms.

1.2.3 Trust as a Psychological State

In such studies, the researchers take it for granted that trust exists and they ask what leads to trust. Cognitive processes and affective reaction are both seen to be such general antecedents [16]. Other antecedents in dyadic trust can be the attitudes of the trustor (disposition, prior experiences, values, motivation) and the trustee (ability, benevolence, integrity) [17, 18].

While the psychological approach gives us an basic understanding of human behavior with regard to trust, it often neglects the context of specific situations.

1.2.4 Bases of Trust

Kramer [19] identifies six different bases for trust. Individuals differ in their psychological predisposition towards trust (dispositional trust). Prior interaction with each other is another base (history-based trust). Trust can also be facilitated by gossip (third parties as conduits of trust). Membership in social or organizational category is the fourth base (category-based trust). Similar is trust in a role – as opposed to a social category (role-based trust). The sixth base is a shared understanding of rules (rule-based trust).

2. Research Methodology

IJVs can be described by contextual turbulence and performance ambiguity [20], thus by complexity. Most IJVs in construction – international construction joint ventures, or ICJVs – are formed to implement mega-projects, which exceed the capabilities of single companies. Recent examples of such projects in Europe are the Channel Tunnel, the Great Belt Link and the Øresund Link. We can easily assert that there is high task complexity. ICJVs are formed by a network of contractual relations between a minimum of two construction companies, design firms, and the organizational network of the client. Again, we can with ease establish the condition of structural complexity. The same holds true by definition of the ICJV for cultural complexity. For all these reasons, it seems imperative to interpret IJVs in the framework of system theory.

Managers plan, organize, staff, direct and control their ICJVs by building them up, running them and dissolving them once the task is fulfilled. Then they move on to their next ICJV. It seems plausible that managers going through these repetitive cycles, perceive, interpret and evaluate their physical, social and institutional world by forming mental frames through interaction. Knowledge thus is produced by this group and becomes intersubjective. This is a constructivist view of epistemology [2]. The constructivist view matches well with the understanding that ICJVs form a specific culture. Weber, based on Kant, strongly advocates that social and cultural research cannot follow the approach of the natural sciences, where laws suffice to describe a static environment following a directly observable causality. A better approach is to discover phenomena as interpreted within the framework of the members of the focal cultural group [21].

Given this background and considering the additional fact that no research has previously been carried out, we used ethnographic interviews [22] to gather data and grounded theory [23] to evaluate and to extract theory from the data [24] regarding trust in ICJVs. In an inverse order to the presentation in this paper, reading of the relevant literature followed data analysis to assure an unbiased approach.

We conducted 35 interviews in the winter of 2003 in Thailand and Taiwan. The interviewees all had experience as managers in at least one and in the majority of cases in several ICJVs. They came from nine different national cultures and represented ten different parent companies. The interviews lasted on average more than one hour and one of the focuses was on the phenomenon of trust. The resulting model of trust in ICJVs is developed in the following chapters.

3. Components of Trust

Trust is definitely a major concern in ICJVs. As one project manager put it: *"I think it's very important when you have a joint venture with one or more than one partner – we have four partners. And I think this was our success, that we trusted each other after a while. We had conflicts, but there was, I want to say, almost absolute trust."* It is surprising to listen to a project manager who just finished a large scale project on time, according to contract, and with a satisfactory profit that he considers the success to be the level of trust achieved in this particular ICJV.

While discovering the relevant phenomena in the gathered data, we will first describe the trust process, then the objects of trust, and finally the consequences of trust.

3.1.1 The Trust Process

Many of the interviewees describe the workload at the beginning of a large scale project as overwhelming. Before the ink has dried under the contract and while the clock is ticking away on contract time, the network between client, designer, contractors, subcontractors, suppliers, authorities, and the public has to be set up, a design encompassing more then a million items has to be proposed, detailed and approved. Planning (quantities, qualities, resources, budgets, subcontracts, suppliers, management plan, safety plan, contract administration, master schedule, production technology, production facilities, accounting system, office organization…), organizing (structure, responsibilities, resources), and staffing (local, foreign, skilled labor, unskilled labor, engineers) of the project overlap each other. Procurement of the lead items, installation of the production facilities, and training of the workforce follow shortly afterwards.

All this must be achieved while the initial engineering team in charge of these tasks is going through the usual phases of forming, storming, norming, and performing. A project manager phrased it as follows: "*But what happens at the beginning of a project in most joint ventures is, …they have won a large project which will have a turnover and a staff that will be equivalent to most medium sized companies. Medium sized companies develop in most cases from small companies, their procedures develop as the company develops, their staff develops as the company develops and so it's a long process that is controlled. What happens in the start of these projects is that you suddenly have to throw a medium to large company together with no procedures, no processes, no understanding, no trust and you throw it into being as an operational organization on day one. And so you have a situation where nobody really knows what the other person is doing, why they are doing it, how they are doing it and even if they should be doing it. And that is the big difficulty in managing these joint ventures because you are suddenly creating a large company on day one and expecting it to operate with the efficiencies of a large company without having any of the benefits of the development time.*" Such is a typical description of what Luhmann calls a complex system.

Analyzing the ICJVs for the construction of the Taiwan High Speed Railway, almost all project managers opted to delegate work. It seemed in all but one case impossible to set up a hierarchy as an organization structure, which concentrates the workload at the top. Instead, all ICJVs (except one) chose a functional organization, thus creating subsystems with the responsibility to break down the assigned partial task complexity. This is all the more astonishing since many of the interviewees represented ICJVs comprising exclusively East Asian countries (Japan, South Korea, Thailand and Taiwan) where according to the findings of Hofstede [25] and Mintzberg [26] a high uncertainty avoidance and a high power distance would typically lead to a hierarchy. The only use of a hierarchy was by a Korean company which had responsibility of a comparatively small contract (around 300 million US$), while the other contracts involved volumes of approximately 1,000 million US$. The given explanation was always that the workload and synchronicity of tasks demanded functional separation. In this case quite clearly the situational determinants had a stronger influence on organization than culture.

The problem of functional separation of tasks is of course the integration towards a solution. This requires under the given circumstances teamwork and trust between members for efficiency. One of the few options to get to grips with the overwhelming complexity is to use trust as a mechanism for reduction. As one manager put it: "*I think what you do, you take trust, you trust everybody at the outset and then you look for the exceptions… I think that's a very general approach. I think it's a general approach for everybody who worked overseas. People that have not worked overseas would tend to have the reverse, okay?… Those that can't trust, quickly get overloaded with work. They end up doing everything themselves.*" If trust is then not reciprocated the consequences are immediate and harsh, the above cited manager would then immediately fire the employee.

Because trust is seen as so important, many managers explained that they would signal trust to their partners from the very beginning: "*We do not expect them that they have to trust us. We have to proof ourselves that we are, what do you call it, to be...trustworthy.*" This trustworthiness is then signaled repeatedly to the other parties. Again and again the same procedures will be repeated until trust is firmly established and then continuously reinforced. For example, a party in charge of the communication with the client, will shortly discuss the contents of each letter before posting with all other parties of the ICJV until they send a return signal, that this procedure needs no longer to be observed.

These findings (immediate trust and active signaling of trustworthiness) are not in accordance with the available literature on IJVs in industries outside construction. Fryxell et al. found that formal control mechanisms produce better performance in the early stages and that their efficiency declines with the duration of the of IJV [19]. Shapiro proposed that trust would develop slowly and build up from minor to major transactions thus requiring more and more trust [26].

On this background the described behavior seems to be irrational. This, however, neglects the basic difference between ICJVs and IJVs. ICJV-systems consist of three groups and contractual relations among them (client, partners, joint venture). In addition, they have to fulfill a written contract in a given time. They have project character. IJV-systems, to the contrary, comprise only two groups (partners, joint venture) and they have neither a written fully specified contract to fulfill, nor a finite budget (the budgets are annually agreed), nor a time limit. Instead, success of IJVs is often measured by the duration of existence.

ICJVs are resembling in the initial phase an adhocracy with high pressure on results. Power which is equivalent to hierarchy is not an adequate mechanism to reduce complexity because of the workload, rules are not an adequate mechanism because they first have to be established, so the only remaining mechanism is trust and to this managers of ICJVs revert. Benjamin Franklin once said: “We must all hang together or assuredly we will all hang separately.” While choosing to hang together there still is the possibility not to hang after all. This describes the attitude towards trust in the initial phase of an ICJV. In a broad sense, the trust at the beginning of ICJVs is a form of category-based trust. ICJV managers trust each other. Yet, the trust seems to be rather forced onto the managers.

Therefore, we will call the described form of trust “necessitated general trust”. It has no time to develop and it is not rooted in face-to-face experience. It is quite obvious that under such circumstances managers prefer to work with people from previous projects in which they have personal trust (history-based trust). This we will call developed face-to-face trust which builds up rapidly in this environment. We would expect that necessitated general and developed face-to-face trust are to a certain degree complementary. The latter replaces the former over time. In the words of a project manager: *“It* [face-to-face trust] *doesn’t develop instantaneously. You know, it’s something that, I would say, feeds on itself. You develop a little bit of trust and people start believing in each other and then it really rapidly increases. But it doesn’t take much of a hiccup to put you back to square one.”*

Luhmann uses the idea of a threshold in connection with trust which was formed in the field of psychology of perception [9]. A zone of benevolence envelops trust and reprimanding action is taken only, if the trustor perceives that the trustee has left this zone. The data suggest that for necessitated general trust this zone of tolerance is rather small and consequences drastic (termination of cooperation). For the developed face-to-face trust the zone is somewhat larger (it takes at least a "hiccup") and the consequences not as severe (after a break-down, work continues and trust-building starts anew). Here, it is important to keep in mind that ICJVs operate for rather short periods, approximately four to five years on average. This limits the growth of the zone of benevolence. Figure 1 illustrates the time-dependent development of both, necessitated general and developed face-to-face trust.

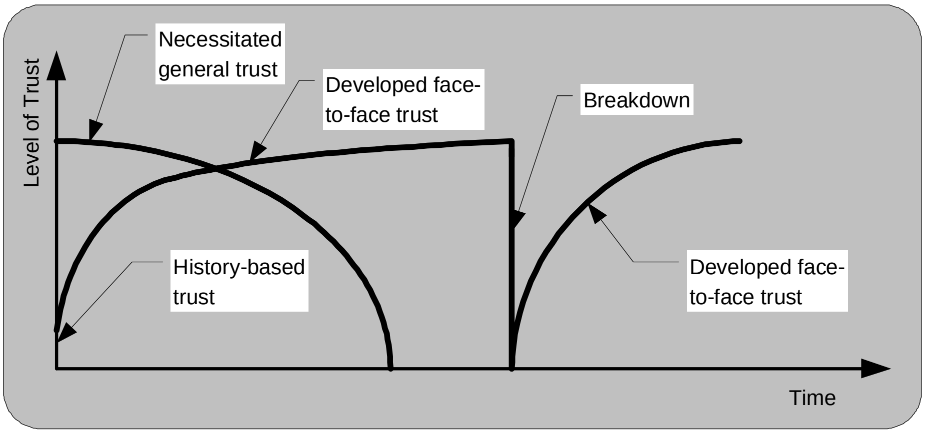

Figure 1: Trust Process

Two annotations are still required: First, for necessitated general trust different national backgrounds within the ICJV are of little importance. For developed face-to-face trust, however, it seems easier to build this within the own culture. *"Of course, it's always easier to build up trust in your own environment, that's very clear. So I think, within the German group it should be easier and the Japanese within the Japanese group it should be easier…"* The overall influence of national cultures is, however, not seen as determining by the same German project manager. Second, the data describe only the behavior directly within the ICJV. Neither trust in the relationship between partners nor between the ICJV and the client follow necessarily the same path.

3.1.2 Objects of Trust

Whom or what do people trust in ICJVs? First of all they place their trust in people. This is not surprising, given the description in chapter 3.1.1 of the start phase: There is not much else, no institutions (rule-based trust), little history. Because of necessitated general trust, managers feel it is important that the people they have to trust should be competent and experienced. Experience is easy to check by looking and the records, competence is deducted from experience. An answer to the question, what is needed to get a team started on a project, is: *"First trust, second is from previous experience these people know that they are competent… So if they worked together already it makes it much quicker to get a team together."*

Most managers want to work with the "right people", especially with people they know. They stress the concept of "right people" in such words: *"They must be experienced, they must have the knowledge to do such work…"* or*: "What kind of people? Okay, I would like to have people who are competent in their area from the technical point of view, whether as construction managers they should have experience in the execution of the work, engineering manager should have experience in the design. Okay, that's very clear, I think."* Experience and competence are mentioned over and over again, and to repeat this, it does not sound surprising considering that an overwhelming workload has to be taken care of.

Trust is also placed into groups. An example is the distribution of work between people from different national cultures, in the words of a Thai manager: *"I trust the Germany for the technical, but I trust Thai people for they solve the problems with the* [public] *authority."*

And finally trust is limited to small groups and to specific issues: "*Yes, trust is...I mean, it doesn't go from the top to the very, very last person, but I think the senior people in a joint venture, they have to trust each other to a certain extent otherwise it makes it difficult, I think. But there probably will be a couple issues where you cannot trust, but you can deal with that. But there should be a general trust that you work together."*

All these conclusions from the data are in accordance with the existing research [1]. A slight difference seems to be the emphasis put on experience and competence.

3.1.3 Consequences of Trust

Trust reduces complexity and therefore the individual workload for two reasons. First, the energy required for controls is minimized. Second, it helps build up a team. A team is tackling separate tasks simultaneously. If there is no need – because of trust – for additional controls, then there is a substantial net saving in time. "*Trust is extremely important. If you don't have trust, the joint venture has difficulties to operate because the whole time too much energy and effort is spend on watching what each partner is doing and not devoting it to the outcome of the project."*

Consequently, people must forgo opportunistic behavior in their daily work. It seems that the losses by an inefficient team are perceived to be greater than the individual gains through opportunistic behavior. The "game" of ICJVs is played repeatedly and the "shadow of the future" looms as large as negative experiences in the past ("shadow of the past"). In addition, the payoff matrix favors cooperation. There were no complains found in the data about occasional opportunistic behavior, let alone wide-spread opportunism. This contradicts Williamson [4], but not game theory [6]. Yet, trust does not eliminate conflicts. Conflicts of interest arise from a different source than mistrust. So they are existing in trustful environments as well. On the influence of trust a project manager observed: " *Yes, yes it* [work] *gets more simple. You also have conflicts, of course, because you have different opinions, but it saves* *time, because if you do not trust each other, then you never know what they are doing, you have to find out where they want to go and so on, trust is just important."*

4. A Model of Trust in ICJVs

The discussion of the components of trust in the previous chapter allows us to build a model of our understanding of the trust process (cf. Figure 2).

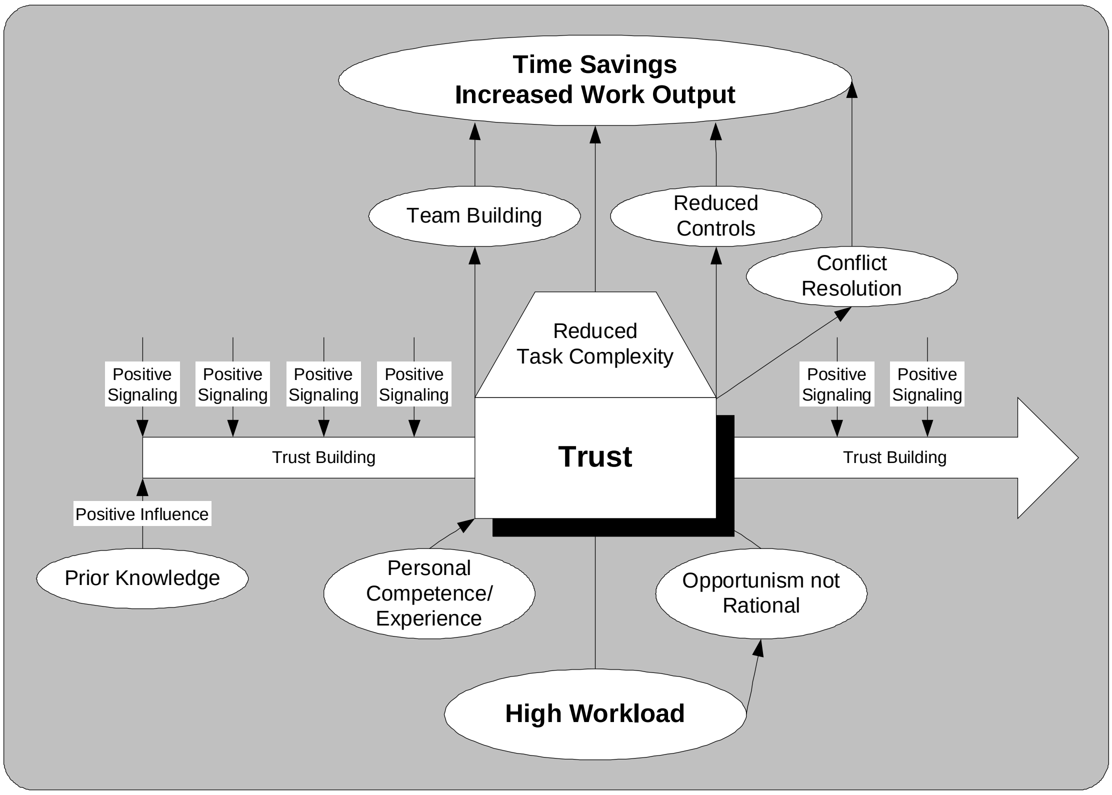

Figure 2: Trust Model in ICJVs

On the vertical axis, a high workload becomes manageable through trust. Personal competence and experience are important antecedents, opportunism is not seen as a rational choice. Trust facilitates team building, thus the possibility of synchronized task solution, and the resolution of upcoming conflicts. In addition, trust sharply reduces the need for controls. Taken together, trust allows getting more work done in a given period of time.

On the horizontal axis the time-dependence of the process is depicted. The positive influence of prior knowledge among colleagues and the need for active signaling of trustworthiness are shown.

5. Conclusions

The most pressing problem of ICJVs is the complexity of the assigned task. To reduce this complexity and thereby to create a much higher degree of order requires a lot of energy. This energy is the workload perceived by managers in ICJVs. In analogy of what happens in a driving school of the introductory example, ICJV managers learn what are effective solutions to this problem as they move from one project to the next and as they work together in a team and communicate with each other. This is a process of sensemaking and creates a mutual understanding of meaning [28].

In this school, ICJV managers learn that their only chance of success is trust: A willingness to extent trust and to signal trustworthiness from the very first day. We termed this "hang-or-die" form of trust "necessitated general trust". It seems to be an idiosyncratic form which is only found in high-pressure environments without established networks. The managers need this trust to perform, but they prefer the personal or face-to-face trust that develops with time. Accordingly they stress their inclination to work with people they know from other projects (history-based trust). If that is not possible, they demand that the others are experienced and competent. Of course, dispositional trust, third parties as conduits of trust, and role-based trust play also a role in ICJVs as in any organizational setting, but these forms of trust are not of focal interest to this study. Rule-based trust is of no importance in the beginning, since all rules in ICJVs need first to be established.

Trust has several beneficial effects. It helps build teams, where trust acts as a bond of tying people together. It reduces energy otherwise required for controls. It helps in cases of conflicts. Overall, it reduces task complexity.

We thank all the unnamed interviewees, who answered our sometimes probing questions with unrelenting openness and trust. They made us feel how they see it.

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Spatial Comparison of Construction Costs: The Basket of Construction Components

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Abstract

The construction sector represents approximately 10.7% of gross domestic product on average — with a lower level of expenditures in developed countries and a higher level in developing nations. Therefore construction sector expenditures play a crucial role in the national GDP calculations and the attendant wealth and standard-of-living comparisons. The International Comparison Program (ICP) of the World Bank performs such comparisons annually, and includes the construction sector under the expenditure heading Gross Fixed Capital Formation. These comparisons result in the formulation of Purchasing Power Parity (PPP). Data is collected for PPP calculations for the construction sector for the residential, non-residential, and civil engineering construction sub-sectors. The resulting PPP values are used for poverty identification and allocation of international aid, which is often provided for the purpose of supporting construction projects as a means of affecting standard of living.

The focus of this paper is the comparison of prices for the construction sector under the International Comparison Program (ICP). In a study conducted by the authors in 2002 a construction-component-based approach was proposed, and termed a basket of construction components (BOCC). This paper describes the implementation framework for the BOCC-based approach. The BOCC methodology can be utilized in the price collection for and formulation of construction sector PPP values. As an additional benefit BOCC can also be used for country-specific temporal construction cost indices. Data collected from a number of countries of widely varying economic condition are used as a proof of concept. The results suggest that the BOCC method can provide an effective means for international price comparison.

Keywords: International construction, international comparison, construction costs, construction estimating, purchasing power parity.

1. Introduction

1.1 Overview of International Construction Cost Comparison

Construction sector spending represents over half of the capital formation spending in most countries [1]. In overall GDP terms construction sector spending equals approximately 10.7% of the GDP—with a lower level of expenditures in developed countries and a higher level in developing nations [2]. Statistics strongly support the fact that the construction sector is an important contributor to global economic growth. Therefore construction sector expenditures play a crucial role in the national GDP calculations and the attendant wealth and standard-of-living comparisons. The United Nations System of National Accounts (SNA) utilized by the World Bank's International Comparison Program (ICP) includes the construction sector under the category called Gross Fixed Capital Formation. The current SNA breakdown provides three basic headings for construction—namely residential, non-residential, and civil engineering. Data is collected for Purchasing Power Parity (PPP) calculations for the construction sector for these three basic headings [3]. In addition to this type of data collection and statistics formulation most countries are also involved in the development and publication of temporal construction cost indices [1].

The PPP value is commonly used in international comparisons in preference to exchange rates, which are more readily available, because it measures something rather different. Where the exchange rate measures the amount of one currency one is willing to pay for a given amount of another currency, the PPP measures instead the ratio of the cost of a set of identical goods in two countries (typically, the US dollar is the denominator). Thus, the PPP represents the ability of the numerator currency to purchase goods, compared to another. Exchange rates should be, seemingly, approximately equivalent, and they are for relatively stable economies and governments. However, exchange rates also capture intangibles such as international confidence and speculation, which can dramatically affect an exchange rate but have little or no impact on a PPP. Thus, the PPP tends to be more stable, and also gives a truer reflection of the economic conditions in a given country (see for example Figure 1).

1.2 Construction Sector Comparison

The complex and variable nature of the construction sector makes it a difficult sector to integrate into standardized econometric systems [2] and as a consequence it is often categorized as a "comparison resistant" sector. The construction industry consists of a complex, fragmented supply chain of owners, contractors, subcontractors, and suppliers. There are no formalized industry structures that represent all of its stakeholders. Its primary output is a series of projects, each resulting in a unique constructed facility. The industry is typified by temporary, contract-driven relationships between the participants of a given project, and this condition makes characterisation and collection of national statistics very difficult to satisfactorily achieve. The lifecycle and timeline of construction projects further complicates collection of prices and their relationship to expenditures in national accounts. It is common to find construction projects with duration ranging from a few months to several years. Furthermore, the industry does not really exist within a given nation; all projects at some point in their supply chains for materials, equipment, or labour, reach out into the interconnected global industry [4].

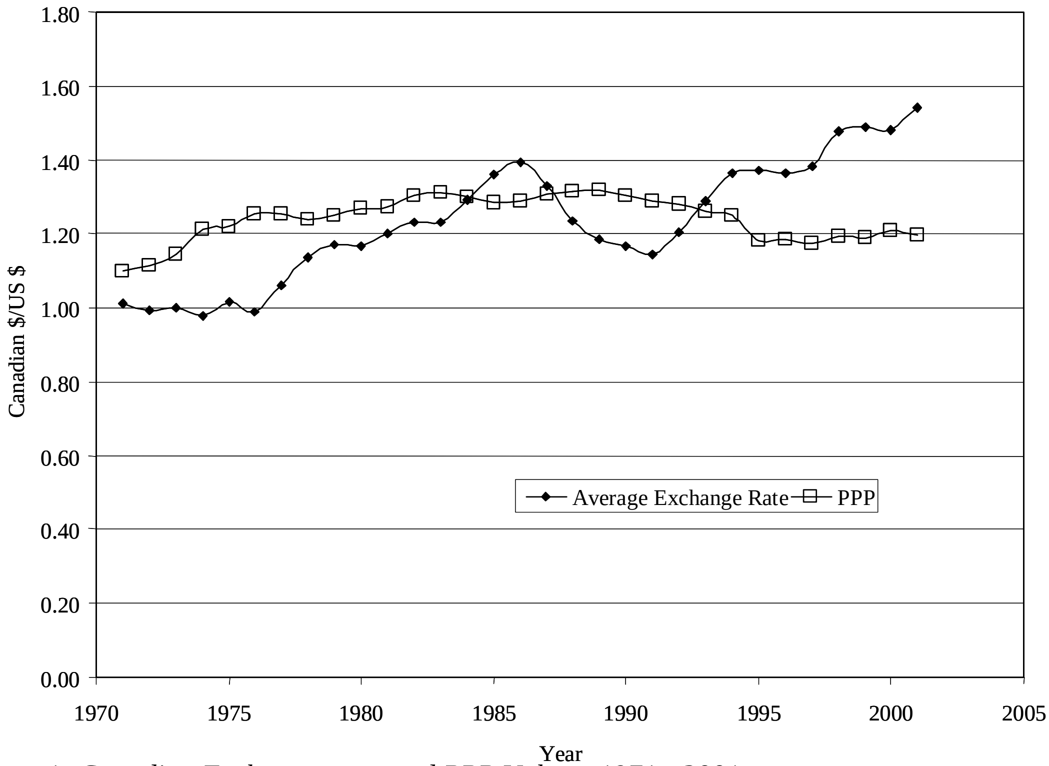

Figure 1: Canadian Exchange rates and PPP Values, 1971 - 2001

Construction products are highly customized to the needs and wishes of the construction consumer. In fact, each and every project is specific to the eventual owner, at the foundation level at a minimum. The net result of this customisation is that it becomes very difficult to compare one project to another. The external influences that are at work on the constructed product are correspondingly unique, and exist primarily at the project level. Economic activity in the construction sector consists of the conversion of materials, labour, and equipment into the unique constructed facility. Variations in these inputs and in the common means and methods used to orchestrate and install them, exist between regions of the world, between nations, and even internally within nations [5].

Because these factors never combine in quite the same way twice, each constructed facility is unique. The cost of a construction project is directly influenced by the selection of means and methods of putting materials in place, the materials themselves, and the labour and equipment rates in use at that time and place. However, there are a number of indirect influences that affect these choices, termed "indirect" here because they modify the selection of materials, equipment, labour, or methods, but will not appear on a bill of quantities themselves. Because construction outputs are inherently difficult to compare, this study was conceived and conducted to further develop concepts for the necessary price comparison in the construction sector.

2. Comparison Methods

Traditionally the calculations for the construction sector were handled by developing estimated costs for 20 standard construction projects [6, 7], for which bills of quantities and specifications have been developed. According to the EuroStat procedures, each bill of quantities requires price estimation for 10 to 20 chapters, each consisting of 100 to 1000 individual construction items [7]. The 1993 round was conducted using the 10-20 chapters. Significant concerns arose about the resource intensity of providing these prices, so subsequently the standard projects method (SPM) has been modified to the so-called “reduced bill of quantities” approach, in which many of the individual items have been eliminated This represents some reduction in effort, although still a substantial number of prices must be selected. There is growing concern that the level of effort and resources required for this process is prohibitive for expansion and continued application of construction sector comparison [7, 8, 9]. In addition to these procedural concerns, it was noted that the results for the construction sector were questionable, because the construction sector result was often very different than the result based on overall consumption. This problem was much more pronounced for developing countries, where representativity and comparability concerns would be expected to be most challenging (Table 1).

Table 1: Overall and construction sector PPP’s, 1985, local currency to US$ [10]

Country	Overall Consumption PPP	Construction Sector PPP
Canada	1.23	1.10
Denmark	10.22	10.04
Finland	6.38	5.38
United States	1.00	1.00
Cameroon	129.1	639.4
Cote D’Ivoire	152.8	341.0
Nigeria	0.861	1.43
Zambia	0.860	0.965

Construction pricing is resource intensive compared to many other sectors because pricing of elements involved in a construction project requires expertise that is not normally available within National Statistics Organisations (NSO) [1, 9]. Such expertise includes familiarity with construction means and methods and experience with recent construction costs. This kind of expertise is usually not available at NSO’s but instead must be acquired (typically on a consulting basis) from construction, engineering, or architectural companies. This makes it mandatory for NSOs to acquire the expensive services of construction industry experts. A study conducted for Economic and Social Commission for Asia and Pacific (ESCAP) concluded that the construction project based comparison currently used is very burdensome for ESCAP countries [1].

Temporal construction price indices are often developed using a basket of construction material and labour prices. This approach causes three problems: a) temporal productivity fluctuations are not accounted for in the resulting index, b) such methods obscure means and methods differences such as different approaches to the labour-equipment trade-off when applied to separate countries, and c) using current methods there is no overlap between the temporal basket of goods and labour approach and the spatial approach (such as for ICP) [1]. Due to this disconnect between the temporal indices produced on a frequent basis and ICP comparisons conducted on a five-year cycle, NSOs find it difficult to garner support and resources for either activity. There is therefore a need for a method that could possibly eradicate both these problems.

Three different broad methodologies for derivation of PPP values exist under the ICP program [2]. The first methodology is used for a majority of the basic headings. Under this methodology prices for commodities form the core of the data collection and calculation. The second methodology is used for non-market services and is based on the cost of commodities and services as indicators of the relevant service [11]. The third methodology was unique for the construction sector and employed a standard project method. This left the construction sector price comparisons disconnected from the main stream of ICP price comparisons [3]. This problem became more pronounced during the 2004 ICP round due to the global adoption of a standard product description and price specification format. Conversion of standard projects into these formats seemed unattainable, further exaggerating the stark differences between construction sector price comparisons and other sectors. This causes many problems for NSOs as it is not easy for countries to readily see uses for ICP construction prices in other areas of statistics [1].

A study conducted by EuroStat in 2002 concluded that "There are significant methodological problems with the current 'bill of quantities' approach, in particular, that it takes a lot of time and effort but the results may still be relatively unreliable" [7]. Some partners of the ICP program have also cast their doubts on the accuracy of the data collected and credibility of the construction estimation process. In a study conducted for ESCAP it was determined that for the 1999 ICP round only 56% of the items that needed to be priced for the standard projects were priced by the ESCAP countries. Further the report documents that out of the 56% prices reported 33.33% were reported partially (where partial coverage means that 10 percent or more of the individual construction units were left blank by the country) [1]. In addition to this issue of partial coverage the price estimation at the construction project level has many pitfalls. Many authors have pointed out that there can be a very wide range in project cost estimates, and that these estimates can compare very poorly to the actual cost of the construction projects [2]. The Construction Industry Institute reported that a range of as much as –50% to +100% compared to the actual project cost can exist on early estimates of industrial projects, and even well done detailed estimates can range through 25% [12,13]. The primary predictor of estimate accuracy is the effort expended to produce the estimate [12], which raises obvious concerns about the ICP given the disparate resources among NSO's.

In light of the foregoing, it seems clear that there is a need to develop methods of comparing construction costs between different nations. Ideally, such comparisons would make data collection and analysis less burdensome and more relevant to participating countries [1]. Because of the peculiarities of the construction sector, however, the comparison must incorporate work put-in-place to be relevant, because only in this fashion can productivity differences and, more importantly, tradeoffs between labour and equipment, to be incorporated in the pricing. The authors conducted visits to a large number of nations during 2004 to observe construction activities. A key observation of this process was that, while the totality of the project might vary from place to place, some components of the construction project were very similar even in different countries (Figure 2). However, it was also observed that in developing countries, labour was used extensively for activities that would likely be mechanized in developed countries.

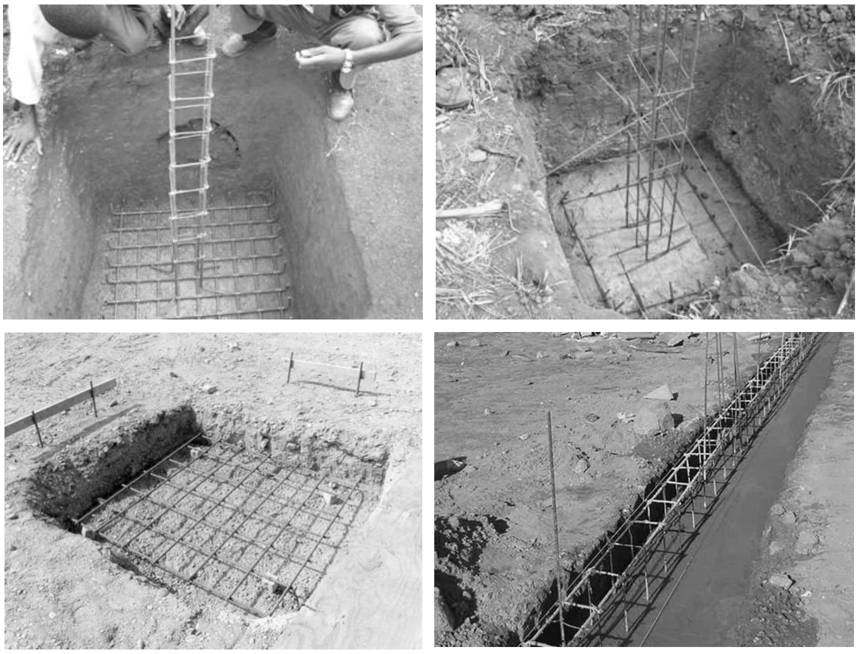

Figure 2: Construction of footing components observed in (CW from top left) Rwanda, Ghana, Mexico, and the United States.

3. Basket of Construction Components Approach

The basket of construction components (BOCC) method that will be used in the construction sector comparisons for the 2005 round of the ICP relies on the collection of prices of selected construction components. A construction component under the BOCC approach is a production unit (e.g. a reinforced concrete column or 100 square meter cement plaster) which can be fully defined as a portion of a complete construction project. The construction component thus falls between a construction project (e.g., a single-family residential unit) and a construction work item (e.g. a piece of reinforcing steel). The construction component can be thought of as an aggregation of several construction work items, including the material actually put in place (e.g. concrete, steel, or lumber), the labour (e.g. the appropriate number of hours for masons, plumbers, or carpenters) and equipment (e.g. dozers, cranes, or dump trucks) required to accomplish that task, and any consumables that might be required (e.g. formwork, blades, or waste lumber). Because the labour, equipment, and consumables are directly included in the price, the construction component inherently accommodates differences in productivity, the labour-equipment trade-off, and differences in means and methods of construction when the price of a basket in one country is compared to that in another country. Due to the inherent nature of the selected construction components they are relatively more comparable and representative as compared to a construction project.

Another unique feature of the BOCC method is that some of the components can be priced inter-temporally. This feature exists because construction components are selected based on their ubiquity in the construction enterprise. As a result, construction components for which prices are collected tend to be composed of materials which are very common globally, such as steel, concrete, etc. Because such constituent materials are so commonly used in the construction components, these materials are also made into stand-alone components. Using such components, and collecting prices for a number of component materials and labour categories, it is possible to build up the component prices for several components. Thus, at a level of effort commonly employed for the calculation of temporal indices in a number of countries, prices of a handful of the BOCC components are priced a number of times in a given year to account for fluctuations in prices over time in a given country. This feature of the BOCC allows countries to see a clear connection between the ICP and their inter-temporal construction indices. This becomes even more beneficial in countries where the BOCC method is adapted as an inter–temporal price index.

In order to describe the implementation details of the BOCC approach it is important to describe the underlying hierarchy of a construction project as it pertains to the BOCC approach. Within the context of BOCC approach a construction project is broken into a number of construction systems and in turn each construction system is decomposed into a number of construction components. Following is a list of generic terms with concept-level definitions for these three levels of breakdown:

- Project: the entirety of a construction enterprise, resulting in a relatively well defined facility for essentially a single purpose. Examples include the construction of a building, the construction of a campus of buildings more-or-less simultaneously, or the construction of a section of roadway including interchanges, bridges, and drainage appurtenances.

- System: a set of related components within a project that satisfy a given function. For example, the structural system within a building would denote that set of components that serve the purpose of supporting the building, and would include foundations, columns, beams, girders, purlins, headers, and so on. It would not include the heating and ventilation equipment or non-structural exterior cladding.

- Component: a combination of materials in their final intended location which can be clearly identified to a simple purpose within the project; the building blocks of a system.

For example, a column. A component will in general consist of some materials manipulated in some way, transported to a final location at the project site, and connected to other components with labour and equipment as appropriate to means and methods employed in a given country.

The relationship between projects, systems, and components is depicted in Figure 3. In this figure a hypothetical project is shown to consist of three systems. Each system is further broken down into its constituent components; with each component made up of material, labour and equipment. In essence, this taxonomy supports a hierarchical discretisation of the project into smaller "chunks". The cost contribution of each component to the total system and project costs can then be developed, using standard construction cost estimating and accounting principles, by rolling up along the branches of the tree. Costs for any given component can be developed from the unit costs of materials (including any necessary consumables) and the expected quantity of materials to create that component, labour rates and labour factors, and equipment rates and factors. Construction cost estimators are very skilled and experienced in making these calculations.

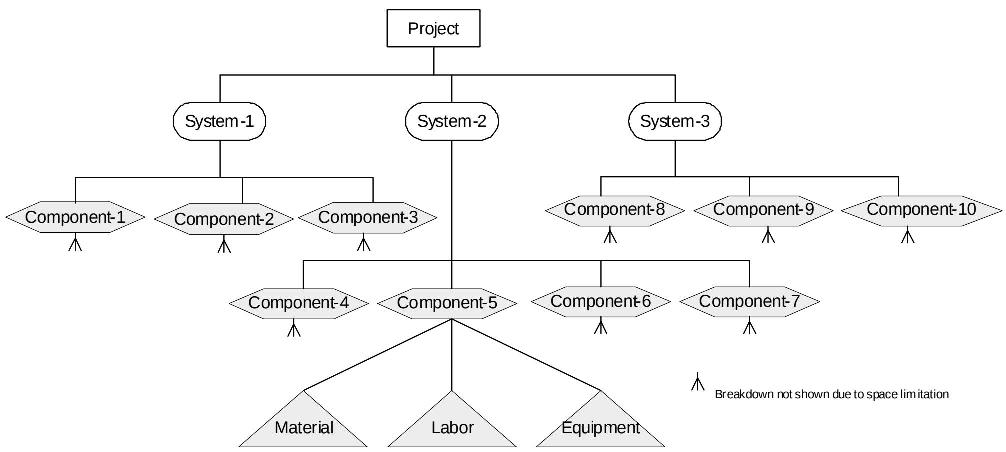

Figure 3: Project, System, and Component Hierarchy

As a proof-of-concept of this proposed method, two components were developed and priced in several countries. The two components consisted of a square reinforced concrete footing (600 mm X 600mm X 250mm) and a reinforced concrete column (300 mm X 300 mm X 3m). Prices were obtained for these two components from national averages reported in year 2000 edition of national estimating guides that are commonly used and readily available. From the sizes of the components, it was possible to develop the quantities of the appropriate constituent materials. The estimating guides provided prices for the materials installed, thus incorporating appropriate labour and equipment quantities and rates. Values appropriate to an urban centre were used; the complexity introduced by differences in construction culture between rural and urban settings are a matter for further study.

This process was performed for the two components for all of the countries listed in Table 2. In the various categories of expenditures for which baskets are priced throughout the systems of national accounts, weighting factors are used to weight the contributions to total expenditures of the individual items within each basket. In this case, as the intent was only to develop a proof-of-concept for the BOCC, the prices for the two components were simply averaged. To the extent that this process was performed for both the numerator and the denominator of the ratio, any error introduced via this simplification should tend to cancel. PPP values for this simple BOCC were calculated for each country by dividing the price in local currency for each component by the price in US dollars for the component in the United States.

Table 2: Comparison between results of simple two component BOCC construction PPP and reported national values for several countries. All values in units of local currency to US$. PPP's in columns 3 to 5 are for overall consumption.

Country	Exchange Rate (2002) [14]	PPP (2002) [14]	PPP (1993) [15]	PPP (1990) [14]	PPP (2000) from simple 2 component BOCC
Cameroon	696.7	210.9	142.4	171.8	118.1
Cote D'Ivoire	696.7	324.3	159.1	168.0	124.9
Ghana	7932.7	1134.2	178.9	94.9	639.7
Nigeria	120.6	46.2	11.5	3.8	19.3
Senegal	696.7	222.2	127.7	185.8	116.4
South Africa	10.5	2.4	1.7	1	1.8
Zambia	4398.6	1893.0	223.4	18.7	501.9
Canada	1.57	1.2	1.3	1.3	1.22
US	1	1	1	1	1

Also presented in Table 2 are currency exchange rates and overall consumption PPP values for each country for comparison with the BOCC results. Note that the year for the BOCC calculations, 2000, does not line up with the year for the overall economic measures. Sadly, estimating guides for the African nations are not produced frequently, and the PPP values are similarly not reported frequently. The two infrequent schedules do not correspond. In order to provide some basis for evaluating the reasonableness of the BOCC results, PPP values from years bracketing the BOCC results are presented in the table.

The values presented in Table 2 reveal several important things about the BOCC results. First, note the extreme discrepancy between the 2002 exchange rates and PPP values in the African countries. This discrepancy was noted in the introductory discussion (see Figure 1), but the effect is much more extreme when considering the developing world. Clearly, exchange rates would be a very inaccurate tool for conversion of prices from one country to another in such cases. Next, while the point was made previously that PPP values tend to be more stable than exchange rates, this is clearly a relative phenomenon. The PPP values from 1990, 1993, and 2000 for the African nations show, as a group, significant changes. Currency exchange rates have experienced even more dramatic shifts for these countries.

Most interesting to the current discussion, however, is the comparison of the 2000 construction PPP values calculated using the BOCC approach and the overall consumption values for 1990 – 2003 reported by the World Bank. The construction PPP's are similar in magnitude and generally within the range of the overall consumption PPP's for the period. Compare this result to the values of construction PPP calculated with the standard projects approach and the overall consumption PPP for 1985 (Table 1), where the construction values differed from the overall consumption values by several times for developing countries. There is no structural or economic reason why the construction sector should experience pricing levels which differ so dramatically as suggested in the 1985 data.

4. Conclusions

Spatial cost comparisons are an important econometric process conducted by international monetary bodies for the purpose of poverty identification, standard-of-living comparison, and ranking of income, production, and economic activity levels. Because the construction sector represents a significant fraction of global economic activity, it is important to incorporate this sector into the overall process accurately. Methods which have been used in recent rounds of the ICP did not appear to accurately capture differences in construction costs between nations. The problem was most extreme for the developing world, which ironically is where construction is most important and need is greatest.

The basket of construction components approach was proposed as a means of improving the comparison process. In this approach, components which are identifiably similar across a wide range of national contexts are defined via standard product description documents. These components include materials, labour, and equipment required to put the defined component into place in the field, and thus inherently incorporate differences in labour productivity and levels of equipment use between countries.

A simple set of construction components was defined and priced in several developing countries and two developed countries. PPP values were calculated for the components by dividing the price in local currency by the price in US dollars for the same component if it were built in the US. The resulting PPP's for construction were compared to overall consumption PPP's reported by the World Bank. The results indicate that the BOCC approach provides construction sector results much more in keeping with the overall consumption PPP's, suggesting that the BOCC-derived values provide a reasonable measure of construction price differentials.

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opinions of the World Bank, the African Development Bank, or the International Comparison Program.

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Globalisation and Strategic IT-enabled AEC Enterprises in Singapore: A Closer Look at the SMEs

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Abstract

Globalisation, rapid technological change and the importance of knowledge in gaining and sustaining competitive advantage characterise this Information Age. Infocomm technology (ICT) serves as a strategic means for enterprises of all sizes to attain global connectivity. This paper presents the results of the IT Barometer Survey of Singapore and looks closely at the state of IT development of the SMEs. Specific recommendations are made to help the SMEs level up by acquiring IT capability. In turn, it will benefit the entire sector as a large proportion of the construction industry is made up of numerous small enterprises which typically lack the financial resources and know-how.

Keywords: IT, globalisation, CORENET, IT Barometer survey, small and medium enterprises (SMEs)

1. Introduction

1.1 The IT Barometer Survey of Singapore

In Singapore, the CORENET programme is part of the IT2000 master plan for leveraging IT to re-engineer the business processes of the construction industry to achieve a quantum leap in turnaround time, productivity and quality. Since its inception in 1993, the AEC enterprises in Singapore have been adapting their practices to the on-going IT development programme. The objective of this paper is to present the results of an industry-wide survey that has targeted over 700 companies. The purpose is to provide a check on industry's response to the CORENET programme in terms of ICT usage and investment at the enterprise level for each AEC group.

In February 2003, an industry-wide survey, entitled, "The IT Barometer Survey of Singapore, 2003", was embarked upon. A total of 84 enterprises responded. The same survey had been applied to countries in the Nordic region where Finland, Sweden and Denmark conducted it in 1998, 2000 and 2001 [1, 2, 3, 4]. Data from the responses to the survey was analysed using the SPSS software.

1.2 The Mailed Questionnaire Survey

The survey form was mailed to a total of 754 enterprises operating in the construction industry in the areas of (i) Architecture; (ii) Engineering; (iii) Quantity Surveying; (iv) Property Development; (v) Construction; and (vi) Product Manufacturing and Supplies. Although the sampling strategy was to involve as many, if not all, enterprises in each category, the larger-sized ones were targeted, especially for categories with numerous companies. A breakdown of the sampling population is given in Table 1.

Table 1: A breakdown of the sampling population, in number and per cent

Category	No. of Enterprises	Per cent
Architecture	361	47.9
Engineering	131	17.4
Quantity Surveying	19	2.5
Property Development	23	3.0
Construction	129	17.1
Product Manufacturing and Supplies	91	12.1
Total:	**754**	**100.0**

The questionnaire comprises a total of 39 questions. They are grouped under 6 distinct headings; Section A: General Information; Section B: Computers and Software; Section C: Use of IT Systems; Section D: Data and Telecommunications; Section E: The Part Played by IT in the Company; and Section F: Standardisation and CORENET.

1.3 The Survey Response

Responses from the survey were analysed using the SPSS software. A more detailed breakdown of the total response is given in Table 2.

Table 2 The rate of response by category, in number and per cent

Category	**No. of Targeted Enterprises**	**No. of Respondent Enterprises**	**Per cent of Respondent Enterprises**
Architecture	361	38	10.5
Engineering	131	15	11.5
Quantity Surveying	19	5	26.3
Property Development	23	2	8.7
Construction	129	10	7.8
Product Manufacturing/Supplying	91	1	1.1
Multi-disciplinary*	-	13	N.A.
Total:	**754**	**84**	**11.1**

A post-verification of the results of the IT Barometer 2003 survey was conducted through the Construction Industry IT Standards Technical Committee in June 2004. This industry-wide committee was set up by the Standards, Productivity and Innovation Board (SPRING Singapore) in collaboration with the Infocomm Authority of Singapore in 1998. Views and comments were elicited from members of the committee for the key findings of the survey. An article had since been published by the SPRING Singapore on the outcome of the IT Barometer 2003 in its technical journal, entitled, Synthesis Journal 2004, as authored by Goh [5].

2. Results of the Survey

2.1 An Analysis of All Response

The results of the survey conducted in Singapore are discussed here and, where appropriate, some selected results from the comparison with Sweden, Finland and Denmark are highlighted. While a few comparisons are country-specific, others look at the Nordic region, involving the countries surveyed in IT Barometer 1998. It is also important to note the time lapse between the surveys. Hence, in the comparison with Singapore, the general approach is to refer to the more recent surveys as those conducted in Sweden and Denmark.

2.1.1 General information

Architects consistently formed one of the largest groups of respondents (see Figure 1).

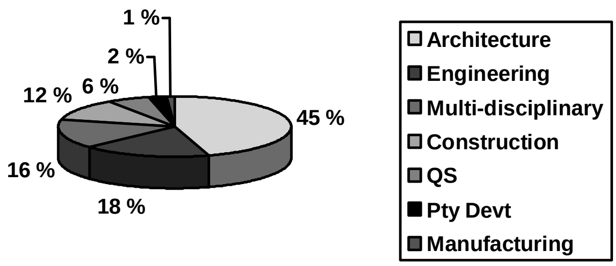


Figure 1: Singapore Survey IT Barometer 2003 (Singapore Survey 2003, Section A)

2.1.2 Computers and Software

By assessing the level of provision of hardware and the types of application software used, an appreciation of the level of exploitation of the technology infrastructure in the organisation can be obtained. Results from the survey on the use of hardware and software are shown in Figures 2 and 3.

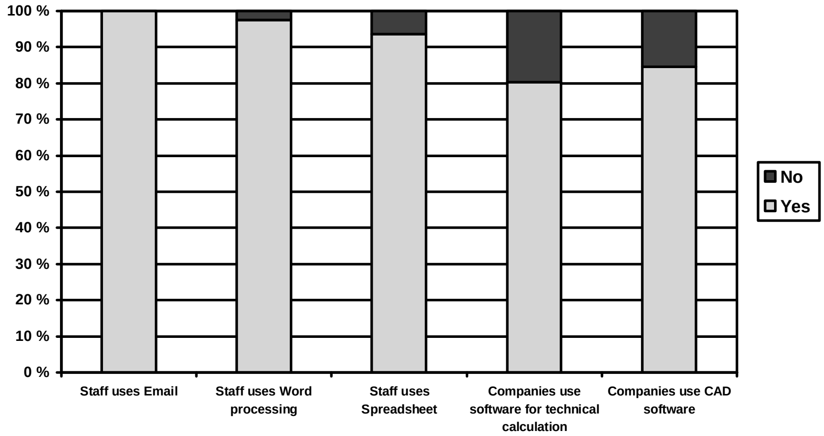


Figure 2: Use of IT hardware in the workplace (Singapore Survey 2003, Section B)

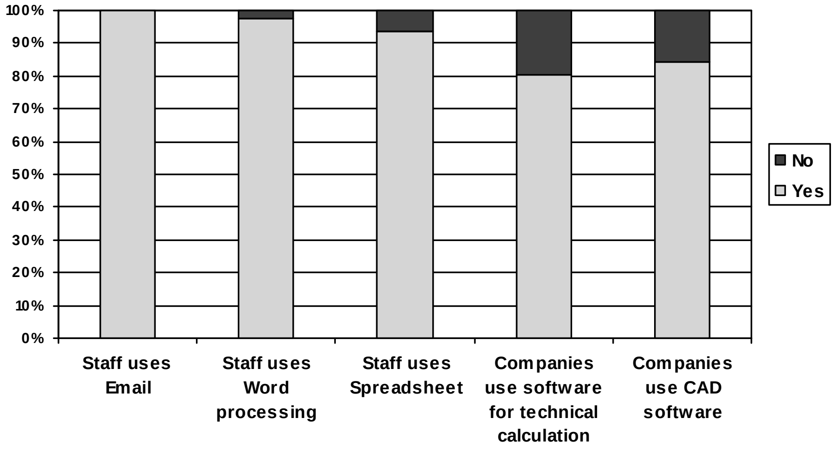
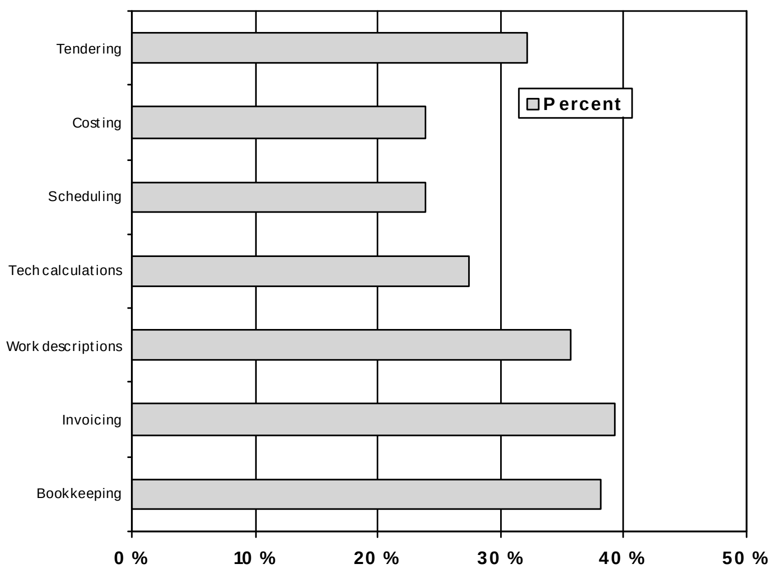


Figure 3: Use of software in the workplace (Singapore Survey 2003, Section B)

2.1.3 Use of IT Systems

The extent of computerisation of the organisation's operations is compared by two broad categories. Between administrative and core business functions, the results have generally indicated, as shown in Figure 4, that the percentage of enterprises that have fully computerised their administrative functions, such as bookkeeping and invoicing, is higher. Hence, enterprises will need to focus more on computerising their core business functions as the next phase of IT development.



Picture 4: Operations that are 100% computerised (Singapore Survey 2003, Section C)

2.1.4 Data and Telecommunications

On global connectivity, having access to the Internet and using web-based applications, such as the Project Web, are indicative of the organisation's capability in this respect. Results of the Singapore analysis as compared with those of the other countries' are shown in Figures 5 and 6.

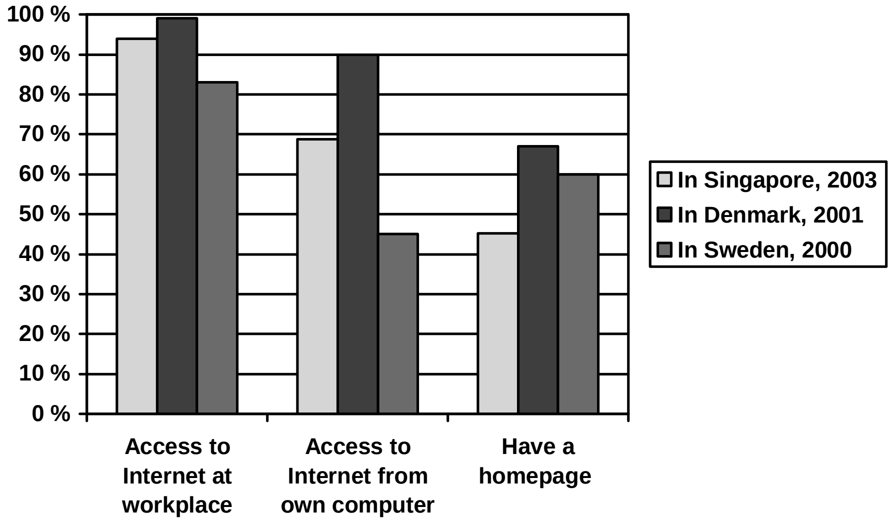


Figure 5: Use of the Internet (A Comparison in Section D)

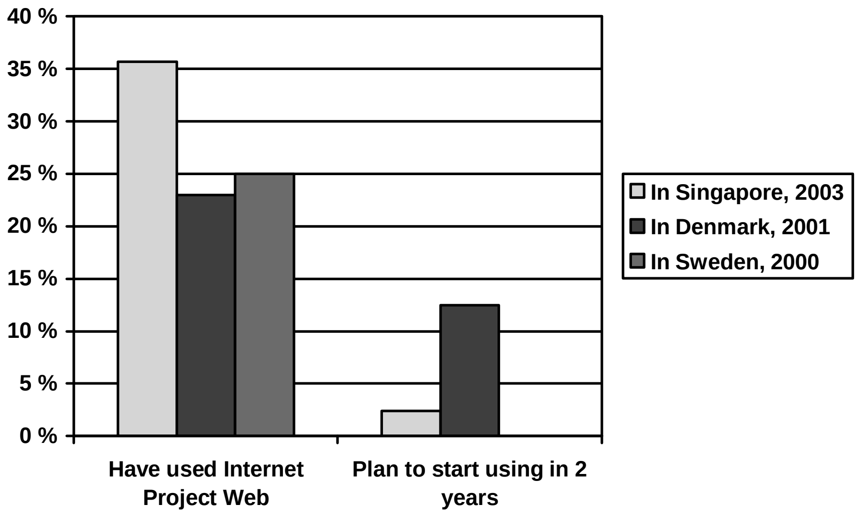


Figure 6: Use of Internet Project Web (A Comparison in Section D)

2.1.5 The Part Played by IT in the Company

The following Figure and tables (Figure 7 and Tables 3 to 6) have summarised the respective countries' findings relating to the role of IT in the organisation and the areas or functions that have benefited from such IT investments, also indicating their advantages.

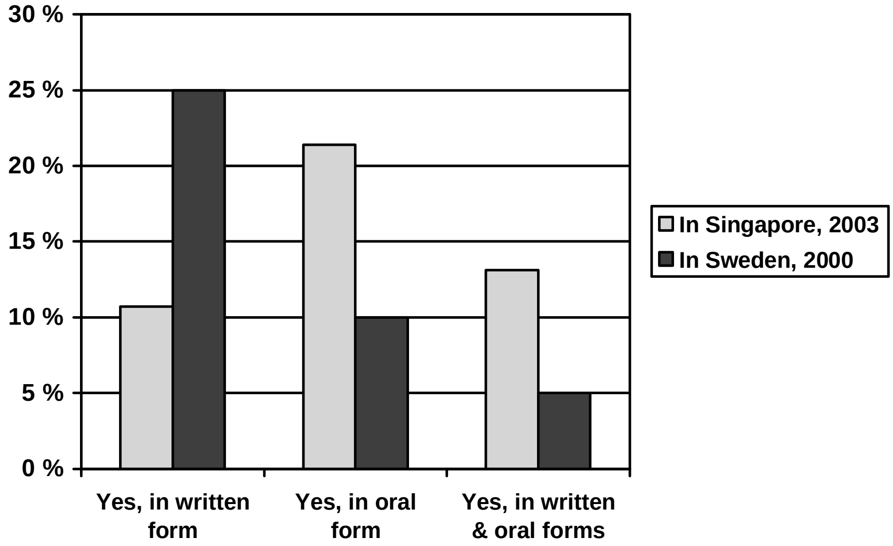


Figure 7: An IT strategy at the workplace (A Comparison in Section E)

Table 3: Ranking of reasons in making decisions about new IT investments

In Singapore, 2003 **Top 4 reasons ranked as "Very Important"**	**In Denmark, 2001** **Top 4 reasons ranked as "Very Important"**	**In Sweden, 2000** **Top 4 reasons ranked as "Very Important"**
1) More efficient technical work. 2) For competition. 3) More efficient administrative work. 4) To be ahead technically.	1) More efficient administrative work. 2) For competition. 3) More efficient technical work. 4) Customer demand.	1) Desire to make administrative work more efficient. 2) Necessary means of competition. 3) Demands from customers. 4) Desire to make technical work more efficient.
The least important reason: - To develop new products/business.	The least important reason: - To develop new products/business.	The least important reason: - To develop new products/business.

Table 4: Ranking of functions that have increased in productivity due to IT

In Singapore, 2003 **Functions that have registered more than 10% increase in productivity (in ranking order)**	**In Denmark, 2001** **Functions that have registered more than 15% increase in productivity (in ranking order)**	**In Sweden, 2000** **Functions that have registered more than 15% increase in productivity (in ranking order)**
1) General administration. 2) Design. 3) Project management. 4) Site management.	1) Design. 2) General administration. 3) Project management. 4) Site management.	1) General administration. 2) Design. 3) Purchase/ Selling. 4) Project management.

Table 5: Ranking of areas which the organisation plans to increase the use of IT

In Singapore, 2003 **Top 3 areas which organisation plans to increase the use of IT (in ranking order)**	**In Denmark, 2001** **Top 3 areas which organisation plans to increase the use of IT (in ranking order)**	**In Sweden, 2000** **Top 3 areas which organisation plans to increase the use of IT (in ranking order)**
1) CAD. 2) Document handling. 3) Project management.	1) CAD. 2) Document handling. 3) Internet.	1) Document handling. 2) Systems for costing/ cost control. 3) Accounting systems. (CAD was ranked no. 7.)

Table 6: Ranking of top advantages that IT provides at the workplace

In Singapore, 2003 **Top 3 advantages that IT provides at the workplace (in ranking order)**	**In Denmark, 1998 & 2001** **Top 5 advantages that IT provides at the workplace (in ranking order)**	**In Sweden, 2000** **Top 5 advantages that IT provides at the workplace (in ranking order)**
1) Work done more quickly. 2) Better quality of work. 3) Faster access to information.	<u>In 1998</u> 1) Quicker work. 2) Quality of work. 3) Faster access. 4) Financial control. 5) Handling data. <u>In 2001</u> 1) Better financial control. 2) Sharing information. 3) Faster access to information. 4) Better communications. 5) Satisfying customers.	1) Better financial control. 2) Simpler/faster access to common information. 3) Better communications. 4) Possibility of sharing information. 5) Easier to handle large amounts of data.

2.2 An Analysis of Categorical Response

The categorical response has been provided in Table 2. With a closer look at the composition of enterprises within each category, it is noted the architectural and engineering categories have enterprises that range from 'Micro' to 'Medium' sizes as based on staff strength. The data is further analysed to draw useful conclusions pertaining to IT adoption by enterprises of different sizes. The main results obtained have been summarised as shown in Table 7.

Table 7: Summary of results as categorised by size of enterprise

IT Barometer Survey in Singapore, 2003	**Micro Enterprise: Up to 10 employees**	**Small Enterprise: 11 to 50 employees**	**Medium Enterprise: 51 to 300 employees**
Section A: General information			
Q4) Percentage of respondents (only Architecture and Engineering.)	31 (58.5%)	18 (34.0%)	4 (7.5%)
Section B: Computers and software			

Q7) Use PC or terminal at work	Yes – 96.8%. No – 3.2%.	Yes – 94.4%. No – 5.6%.	Yes – 100%.
Q8) Types of software used at work	Word processing – 90.3%. Spreadsheet – 77.4%. Email – 93.5%. Admin. – 51.6%. Tech. calculation – 67.7%. Time planning – 25.8%.	Word processing – 83.3%. Spreadsheet – 77.8%. Email – 83.3%. Admin. – 77.8%. Tech. calculation – 50.0%. Time planning – 61.1%.	Word processing – 100%. Spreadsheet – 100%. Email – 100%. Admin. – 75.0%. Tech. calculation – 100%. Time planning – 100%.
Q10) Staff access to the IT equipment	Own PC – 97.6%.	Own PC – 98.1%.	Own PC – 95.0%
Q12) CAD software at the workplace	Yes – 90.3%.	Yes – 94.4%.	Yes – 100%.
Section D: Data and tele-communications			
Q20) Access to the Internet at the workplace	Yes, via an analogue modem – 48.4%. Yes, via ISDN – 12.9%. Yes, via a permanent connection – 29.0%. No – 3.2%.	Yes, via ISDN – 50.0%. Yes, via a permanent connection – 44.4%. Missing data – 5.6%.	Yes, via an analogue modem – 25.0%. Yes, via a permanent connection – 75.0%.
Q22) Have a Home Page on the Internet	Yes – 19.4%. No, it does not need one – 48.4%. No, but it ought to have one – 25.8%.	Yes – 61.1%. No, it does not need one – 16.7%. No, but it ought to have one – 16.7%.	Yes – 100%.
Q23) Have used an Internet Project Web for storage and transfer of project documents	Yes – 19.4%. No, it is not necessary – 54.8%. No, but it would be useful – 16.1%.	Yes – 66.7%. It is planned to use in 2 yrs’ time – 5.6%. No, it is not necessary – 11.1%. No, but it would be useful – 11.1%.	Yes – 75.0%. It is planned to use in 2 yrs’ time – 25.0%.
Section E: The part played by IT in the company			

Q26) Have an IT strategy at the workplace	Yes, in written form – 3.2%. Yes, in oral form – 25.8%. Yes, in both written and oral forms – 9.7%. No, it is not necessary – 32.3%. No, but one is needed – 19.4%. Do not know – 6.5%.	Yes, in written form – 11.1%. Yes, in oral form – 27.8%. Yes, in both written and oral forms – 5.6%. No, it is not necessary – 38.9%. No, but one is needed – 11.1%.	Yes, in written form – 25.0%. Yes, in both written and oral forms – 75.0%.
Q30) Importance of listed reasons in making decisions about new IT investments	Top 3 reasons ranked as "Very Important": More efficient technical work. (58.1%) More efficient administrative work. (38.7%) To be ahead technically. (35.5%)	Top 2 reasons ranked as "Very Important": More efficient technical work. (61.1%) More efficient administrative work. (38.9%) 2) To be ahead technically. (38.9%)	Top 2 reasons ranked as "Very Important": More efficient technical work. (100%) For competition. (75.0%) 2) To be ahead technically. (75.0%)
Q32) Effect IT has on productivity in the last 2 years	Respondents have registered firmly an increase by more than 10% in productivity in the following functions (in ranking order): Design. (54.8%) General administration. (45.2%) Project management. (29.0%)	Respondents have registered firmly an increase by more than 10% in productivity in the following functions (in ranking order): General administration. (55.6%) Design. (55.6%) Project management. (38.9%)	Respondents have registered firmly an increase by more than 10% in productivity in the following functions (in ranking order): General administration. (100%) Project management. (100%) Design. (100%)
Q33) Areas the company plans to increase the use of IT in the next 2 years	Top 3 areas: CAD. (96.8%) Document handling. (35.5%) 2) Internet info. searches. (35.5%) Portable/Mobile systems. (32.3%)	Top 3 areas: CAD. (83.3%) Project management. (55.6%) Document handling. (50.0%)	Top 2 areas: Project management. (100%) CAD. (75.0%) Document handling. (75.0%) Project webs. (75.0%)
Q34) Advantages that IT provides at the workplace	Top 3 advantages: Work done more quickly. (83.9%) Better quality of work. (71.0%) Faster access to information. (58.1%)	Top advantage: Better quality of work. (66.7%) Work done more quickly. (66.7%) Faster access to information. (66.7%)	Top 2 advantages: Sharing information. (100%) Better quality of work. (75.0%)

3. Discussion of Findings

Some of the results shown in Table 7 will be elaborated. The primary objective is to establish whether company size relates to how and why organisations use IT. As explained, the small and medium enterprises (SMEs) of the architectural and engineering disciplines are examined here.

Firstly, on computers and software, larger companies tend to regard IT as a functional necessity. The results have shown that all ‘Medium’ enterprises use PCs and the CAD software at the workplace (100%).

Secondly, on global connectivity, the larger companies tend to regard Internet access as a permanent facility and, hence, have a Home Page on the Internet. They would also have used project collaborative applications in their course of work. The results have provided strong evidence for the ‘Medium’ enterprises in the areas mentioned.

Thirdly, on the strategic use of IT, the larger companies tend to formalise their IT strategy, go beyond computerising administrative functions and consider IT as a collaborative enabler. The results have indicated that the ‘Medium’ enterprises either have an IT strategy in written form (25%) or in both written and oral forms (75%). They view using IT for competitive advantage as very important and plan to increase its use in areas that enhance technical quality (CAD and Project management) and collaboration (Project webs).

4. Recommendations for Smaller Enterprises

Typically, a large proportion of the construction industry is made up of numerous small enterprises. In Singapore, 68.6% of the total number of enterprises in the construction industry has less than 10 persons employed, while 23.8% has 10 to 49 persons [6]. In view of the inherent structure of the industry and the general tendency for larger enterprises to favour the use of IT, promoting this technology to smaller enterprises becomes more crucial to bring about industry-wide connectivity. The recommendations for the respective areas of concern are as follows:

1) A large number of small firms are interested in introducing IT but have difficulties in finding the financial resources. It is recommended that policies be aimed at upgrading programmes that can reach very large numbers of SMEs through market-led programmes and design mechanisms that are easily accessible to the SMEs at an affordable price.

2) Small firms lack the ability to specify their exact requirements and tend to buy much more expensive and complicated systems than required. It is recommended that policies be aimed at promoting continuous growth of the software and services industries to benefit both local users and providers.

3) Small firms do not adopt formal strategies and hence are unable to measure any benefits derived from IT against business performance targets. It is recommended that conditions

for awarding government assistance grants to require the incorporation of business strategies into proposed IT investment plans.

4) The culture in small firms tends to be people-oriented which brings about specific needs when implementing change. It is recommended that focus be placed on top leadership commitment and support, and a formal reward or compensation structure be put in place to bring about effective diffusion. Besides rewards, employees expect easy-to-use systems that are compatible with their normal work routines.

5. Conclusion

In order to benefit from globalisation, and from foreign competition in the domestic market, countries need to establish competitive capabilities beyond cheap labour. Whatever strategy is used, staying competitive requires investments in IT to develop world class information systems. In addition to staying competitive in the domestic market, enterprises that make these investments are also setting the stage for competing in international markets. The global production networks of many industries are moving quickly to integrate the entire supply chain electronically.

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Section II

Models for improved understanding of global issues

Applying Porter's Frameworks to Managing A Business in Global Construction Markets

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Abstract

The purpose is to introduce and advance a population of the nine applications of Porter's frameworks to managing a firm's business(es) in global construction markets. Betts and Ofori (1992) recommend Porter's frameworks as strategic planning techniques. Winch and Schneider (1993) suggest a model for architectural practices. Veshosky (1994) has applied the strategies to the A/E firms in the USA. Jennings and Betts (1996) have re-defined the strategies for quantity-surveying practices. Pinto et al. (2000) establish customer-based project-success metrics. Huovinen (2001) introduces five competitive arenas. Langford and Male (2001) address product differentiation. Rapp (2001) links low cost, differentiation, and speedy response. Kale and Arditi (2002) recommend a neutral approach to scope with all the modes of competition. Finally, it is suggested that these existing and new applications be advanced further as a causal chain of Porter's frameworks in the various contexts of global construction markets. @b@1@e@1@b@2@e@1

Keywords: Business management, competitive strategies, construction market, literature review, Porter Michael E.

1. Introduction

This paper is one of the outcomes of a 4-year literature-review process [1]. **A review problem** of how a firm's dynamic business can be managed successfully was approached in light of both the generic business-management concepts and their construction-related applications published between the years 1990-2002. This focus on **business-level management research** is based on the author's perception, i.e. managing a single business successfully is at the same time the most challenging and the most enduring level of strategic management. During the review, the converging versus diverging answers of the various authors were identified concerning the question "What is the primary way (element) of managing that will enable managers to set challenging business goals and also to attain them?" Thus, this business-management research was regrouped into **the eight broad schools of thought in business management** as follows: Porterian, resource-based, competence-based, knowledge-based, organization-based, process-based, dynamism-based, and evolutionary school [1 p. 89].

In this paper, **the sole focus** is on Porter's frameworks and their construction-related applications. This is so because the Porterian school seems to dominate, i.e. the total number of the practitioners applying Porter's frameworks across industrial, service, and construction businesses is still likely to exceed the combined number of the practitioners relying on the outcomes of the other seven schools. Typically, Mintzberg et al. [2 pp. 352-3] acknowledge that Porter's "positioning school" remained highly influential in terms of the annual "activity" (amount of publication and attention from practitioners) in the late 1990s. However, it seems that not even the Porterian school can show empirical evidence of sustained good business performance (e.g. [3]). In the early 1990s, Porter [4 pp. 428-9] emphasized that **the theory embodied in a framework** is contained in choosing its elements and variables, i.e. the way these are organized into a framework, their interactions, and the ways in which alternative patterns of variables and firm choices affect outcomes.

The purpose of this paper is (a) to introduce the cumulative chain of Porter's frameworks, (b) to review the nine applications of Porter's frameworks for managing a firm's business in global construction markets, and (c) to suggest some promising ways of advancing the applicability and effectiveness of the same and new applications of Porter's business-management frameworks in the future as follows.

2. Porter's Business-Management Frameworks

2.1 Porterian school of thought in business management

Herein, the introduction of **the Porterian business management** is based only on Porter's references and Porter and Wayland's [5] contribution that are all (re)published between the years 1990-2002. Among them, there is only one integrated account of the development of his frameworks. Porter's [4 pp. 431-9] chain of causality connects firm behaviour and business environment to competitive market outcomes. Porter offers **a set of cross-sectional strategies** to managers as follows:

§ A contextual market strategy for choosing the attractive, strategically distinct business(es); based on gaining the knowledge of the five forces inherent in each business or competitive arena [6, 7]

§ A positioning strategy for choosing, building, and sustaining a firm's attractive relative position in the targeted business; based on choosing incompatible trade-offs with alternative positions [4, 6, 7, 8]

§ A competitive strategy for choosing, creating, and upgrading competitive advantage(s) within a firm's competitive scope; based on aligning a firm's activity system, resources [including competences], and organization to the adopted strategy as well as refining these according to exogenous changes; by using the underlying structural drivers [4], [7, 8, 9, 10]

§ A coherent set of guiding principles for reconnecting a firm with strategy and a firm's strategy with its operational effectiveness as well as for strategizing during the Internet era [8, 9, 10]

§ A locational strategy for managing a firm's membership within a vibrant cluster [4, 8, 11, 12, 13, 14, 15].

2.2 Relevant critique of construction-related scholars

Over the years, strategic management scholars have criticized Porter's causal chain of frameworks, typically, in terms of choosing positioning as the only strategy, organization, people, and resources that are missing, meta-strategies homogenizing firms, and their realist premises. Herein, only **the relevant critique of some construction-related management scholars** is reviewed as follows.

In the early 1990s, Fellows [16] argued that **Porter's [7] five forces model** is derived from the traditional view of competition (the perfect competition-monopoly continuum); therefore, it does not appear to take account of the theory of contestable markets. Porter's approach is too narrow, i.e. a supply-side analysis. In addition, developed markets were recognizing the limitations of competitive perspectives and were moving toward cooperation. Thus, appropriate strategies are based on gearing the supply side to the greatest likelihood of maximizing demand-side satisfaction. In their reply to Fellows, Betts and Ofori [17] admitted that it is fair to say that Porter's (1980, 1985) work had come under some criticism as an over-simplistic and populist approach. Yet, irrespective of its weaknesses, it cannot be doubted that the work had [already] made much impact and, on this basis, Betts and Ofori (e.g. [18]) considered it justified to apply Porter's strategic planning principles to construction.

Winch and Schneider [19] have posited that, while very attractive, **Porter's [6] generic strategies** were developed for manufacturing industries. Thus, these strategies are not immediately applicable to professional practice. E.g. cost leadership, which is the result of heavy capital investment or preferential access to material inputs, is un-attainable in professional practice due to its labor-intensive nature and the lack of inputs.

Later, Jennings and Betts [20 pp. 165, 176] recalled that **Porter's competitive strategy theories** had readily been applied to the [UK] construction industry. They found out that Porter's [7] generic strategies might generally be suitable for use by private quantity-surveyor practices. However, the analysis of the traditional professions associated with construction is not so straightforward due to their service-based and knowledge-based nature. In particular, the unpopularity of cost leadership indicates that Porter's work does not provide a balanced definition of competitive strategy for PQS practices.

In turn, Kale and Arditi [21 p. 238] sum up that construction-management researchers have been preoccupied with **the concept of competitive positioning** and its performance implications for quite some time. They consider that these works have provided important insights on this concept in the context of the construction industry. However, this research appears to be unbalanced in favor of anecdotal or descriptive approaches. Only a few researchers have empirically explored this concept (Jennings and Betts 1996) and its performance implications.

3. Construction-Related Applications of Porter's Frameworks

3.1 Review of the Construction-Related Business-Management Concepts Published Between the Years 1990-2002

Hart's [22] guidelines were applied to conducting **the review** during the years 1999-2003. **The replicable ways** of searching, browsing, in-/excluding, retrieving, inferring, coding, describing, and analyzing the applied data were used and documented. The books of nine construction-related publishers and 25 journals were browsed extensively (see [1]). The generic nature of managing a firm's business was maintained by limiting the search only for the concepts where the focal firms are based in the OECD countries. The only exception was to allow the references originating from Singapore or Hong Kong to be included in the applied data; due to the authors' British Commonwealth heritage and interests in global business issues, too.

Global construction markets deal with design, implementation, services, and life-cycle aspects of investments in the utilization of natural resources, energy supply, tele-communications, transportation, other infrastructure, manufacturing, and general building concerns. **Business dynamism** includes the total spectrum of managing a firm's business in static, dynamic, cyclical, hypercompetitive, and even chaotic markets. A population of firms operating in global construction markets involves various kinds of contractors, designers, suppliers, and service providers.

The review resulted in identifying **a population of 38 construction-related business-management applications** published between the years 1990-2002. Overall, the key finding is that no research tradition exists concerning construction-related business management.

3.2 Nine Construction-Related Applications of Porter's Frameworks

One of the sub-reviews resulted in the identification of **nine references** where the authors apply one or several Porter's frameworks to managing a firm's business in (global) construction markets. The authors, their applied concepts, broad business contexts, and eventual empirical evidence appear in Table 1. Herein, the rule of neutralism [22] is maintained by quoting the authors' original texts (without adding the reviewer's own interpretations). In this way, a reader can judge the validity of each concept for her or his own theoretical and/or practical point of view, and (s)he can then act accordingly (e.g. to acquire a valid reference).

(1) In the early 1990s, Betts and Ofori [18] found out that strategic planning was beginning to be adopted by many [UK-related] construction enterprises, and they concluded that strategic planning techniques [such as Porter's **frameworks**] were vital for the survival and progress of construction enterprises of all types.

(2) In turn, Winch and Schneider [19] suggested a strategic model for [the UK] architectural practices, which is based on Porter's (1980) **generic strategies** and developed from Maister's [23] strategy model for professional practices. This model highlights strong delivery, experience, ambition, and ideas as being **four key strategies** that architectural practices follow, based on the parameters of project complexity and the client's quality preference. They admit that architectural practices are notoriously difficult to manage. A major requirement is a sense of vision – an understanding of the distinctive competence, the underlying culture, and the awareness that to be effective, the whole and the parts need to be consistent with that vision.

(3) Veshosky [24] used Porter's [6] **generic competitive strategies** as a basis for developing an analytical framework and applying this to the design segment of the A/E/C industry in the USA. He elaborated the content and the use of cost leadership, differentiation, and focus on a niche. He concluded that, while strategy concepts may be implicit in decision-making by managers of A/E firms, the formulation and implementation of explicit business strategies appear likely to be superior to strategies that occur by default, resulting from the decisions of autonomous managers.

(4) Jennings and Betts [20] have combined Porter's [7] **generic strategies** and Maister's [25] three benefit elements with the results of their study in order to define **four new generic strategies** (execution, expertise, efficiency, and experience) for private quantity- surveying (PQS) practices. They argue that their model represents a contribution to classifying and forecasting the way in which PQS practices compete, and how they utilize IS/IT to help achieve their goals. Each PQS generic strategy identifies a typical practice size, an IT-use level, strategy elements, and a staff structure.

Table 1: Applications of Porter's frameworks to managing a business in global con-struction markets. The references are published between the years 1990-2002 (n = 9).

Author (year)	Porter's original framework	Applied, contextual framework	Business context	Empirical evidence
Bets and Ofori (1992) [18]	5 forces (1979), generic strategies, value chain (1985)	(1) Relevance, scope, and ways for applying them in construction	Construction enterprises	No new empirical data
Winch and Schneider (1993) [19]	Generic strategies (1980); Maister (1982)	(2) 4 generic strategies (strong delivery, exper-ience, ideas, ambition).	Architectural practices in the UK	No new empirical data
Veshosky (1994) [24]	Generic competitive strategies (1980)	(3) Analytical frame-work and its application to the design segment of the A/E/C industry	Architecture/ engineering (A/E) firms in the US	Interviews of 11 firms. Explicit strategies are superior to ones occurring by default.
Jennings and Betts (1996) [20]	Generic strategies (1985); Maister (1986)	(4) New generic stra-tegy model to PQS practices with IT support	Private quantity surveying pract ices in the UK	Survey (n = 47). Suit-able strategies except the cost leadership.
Pinto et al. (2000) [26]	Value-chain model (1985)	(5) Value-chain analysis of a project supplier	International offshore contracting	Aker Rauma Off-shore A client-driven model of project success.
Huovinen (2001) [27]	5 forces model and generic strategies (1980,1985)	(6) Framework for de-signing an international competitive strategy	Technology-intensive contracting	Case contractor (based in Finland)
Langford and Male (2001) [28]	Competitive industry forces framework (1980)	(7) Adapted 5 forces shape the construction -industry structure	The UK construction industry	No new empirical data (textbook)
Rapp (2001) [29]	5 forces model, value chain (1980, 1985)	(8) Adapted 5 forces, speedy response, and client value chain.	The US construction industry	No new empirical data
Kale and Arditi (2002) [21]	Competitive posi-tioning 1980, 1985, scope and mode of competition	(9) Mode: cost, quality, time, innovation. Scope: geography, delivery systems, and clients	The US construction industry	Survey (n = 93). Em-phasis on all 4 modes and a neutral scope outperform rivals.

(5) Pinto et al. [26 pp. 106-109] have adapted Porter's [7] **value-chain model** to establishing a Finland-based project supplier's customer-based project-success metrics. Their value chain analysis suggests that firms can compete most effectively if they clearly understand how they can help create value to their customer's business-activity cycle. Besides the traditional determinants (time, budget and performance), a client-driven model (quality and customer satisfaction) drives all strategic project decisions. In a highly competitive industry, superior products go hand-in-hand with superior service. Thus, it is the sum of all activities in the value chain that counts. Weak areas can be offset by strong advantages in other activities.

(6) Huovinen [27] has segmented capital-investment markets into **five competitive arenas** across the globe. Within each arena, there are various investors which contractors target as their potential clients. Each arena consists of a series of competitive bidding situations. In turn, each situation involves one investor and competing contractors, which aim at preparing the best bid, offering the most beneficial investment solution, and finally winning the contract. A new framework is based on the idea of **the creation of the best fit between the primary decision maker**, i.e. the investor in question (with its investment need and process), and the most competent contractor (with its investment solution and delivery process). The framework consists of four areas: (a) business scope and objectives, (b) marketing and sales, (c) investment solution, and (d) contract fulfilment. The emphasis is on managing three kinds of relationships among the investors, the CASE contractor (and the partners), and its strongest competitors. It is applied to a context where a technology-intensive contractor is setting objectives for its future competitive positions in international capital-investment markets.

(7) Langford and Male [28 pp. 44-55] have adapted Porter's [6] **five forces framework** to the UK construction industry. The industry provides the longer-term structural context whereas the market translates it into a short-term exchange relationship for setting up a geographically located production process. Products are either service-products or end-products. The service-product embodies reputation and **product differentiation** occurs through clients' pre-qualification, procurement, and tendering mechanisms. Substitute products or services (undertaking the same function) are not an easy concept to apply in the construction industry. A functional analysis of the end-product substitution (process) suggests that the underlying purpose is to provide the client with a facility that allows organizational and business processes to proceed optimally. Thus, the solution for the client may not be in constructing a new facility but renovating, refurbishing, or maintaining an existing facility.

(8) Concerning the US construction industry, Rapp [29 pp. 37-42] has linked Porter's –[6], [7] **competitive industry-forces model** (with three modes of low cost, differentiation, and speedy response) with the emphasis on the competitive vertical dimension (new rivals and substitutes) and the primarily cooperative horizontal dimension (suppliers and customers). Current competition may range from avoided competition to hypercompetition. Porter's (1985) **value chain** is viewed as the client-value chain, where activities may be intermingled and iterative, depending on project-delivery mode and urgency.

(9) Kale and Arditi [21 pp. 241-6] have adopted Porter's [6], [7] generic competitive positioning typology, but they have classified **four modes of competition** somewhat differently, and explored this concept and its performance implications in the context of the US construction industry. Overall, significant differences in offerings are absent, which makes it favorable to compete solely on the basis of one mode. But this cannot be sufficient for gaining and sustaining competitive advantage. The survey findings support this assertion by pointing out that a cluster of the companies, which adopt a neutral (between a narrow and a broad) approach to scope and place a strong emphasis on all four modes of competition (quality, innovation, time, and cost), outperforms their rivals. This hybrid mode of competition contradicts Porter's original proposition that combining different modes of competition is not a viable approach.

4. Conclusions

In summary, **the applicability** of the nine applications varies a lot. In part, this seems to be due to the strictly scientific policy of publishing, i.e. the authors are not allowed to address the applicability of their concepts and the related user-instructions-issues. Thus, this concluding discussion involves the positioning of nine applications into a causal chain of Porter's [4 p. 432) frameworks and some suggestions for advancing both the existing and new applications further across various contexts of global construction markets as follows (Figure 1). Interested scholars can readily take into account the critique of some construction-related management scholars (see pp. 3-4).

Overall, construction-related management scholars can adopt **Porter's chain of causality** as a frame for advancing their applications. It is possible to explain, at least ex post, **”Why was a construction firm's cross-sectional strategy (non-)successful at a given point in time?”,** that is given a particular competitive position, competitive advantage, activity system, and/or a set of drivers of the firm (cf. [30 pp. 92-3]). At the broadest level, a construction firm's success is a function of two factors: the attractiveness of the global business in which the firm competes and its relative position in that business. A position is an outcome and not a cause. Why or how did this position arise? The firm possesses a sustainable competitive advantage (e.g. lower costs or differentiation) vis-à-vis its rivals within its chosen competitive scope. Again, why. In order to address this, cost, differentiation, and scope must be decomposed. This requires a theory that provides an elemental look at what firms do. A construction firm involves

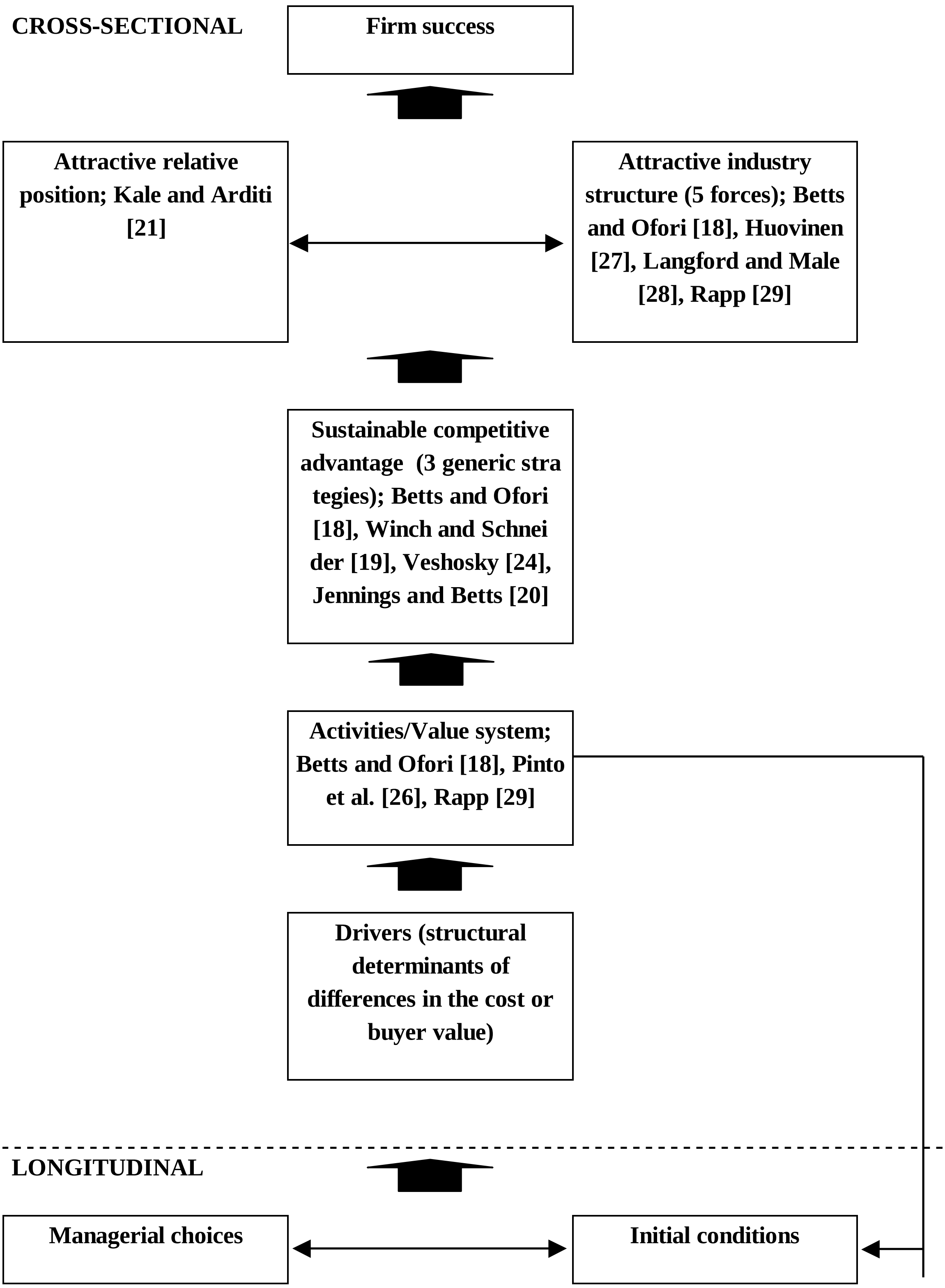

Figure 1: Porter's determinants of success in a distinct business as a chain of frameworks [4 p. 432). The nine references containing the construction-related applications are coupled with the related frameworks.

A system of discrete but interrelated economic activities - Why was this successful? Activity drivers are structural determinants of differences among competitors in the cost or buyer value of activities or groups of activities. Tying advantage to specific activities/drivers is necessary to operationalize the notion of competitive advantage in practice. Ex ante, Porter's [4] view of the origin of advantage is that it lies in the ability to make good strategy choices and implement them. New choices are made as the environment changes or as accumulating activities and resources open up new options.

In addition, construction-related management scholars can make use of Porter's [15 p. 16] work on operational effectiveness and positioning which begins to bridge positioning, location, and **dynamic improvement** to a firm's competitive advantage. It stresses the necessity of continual improvement in operational effectiveness but emphasizes the need for continuity in strategy, along with the concomitant need for relentless improvement in the means for carrying out strategy. Both operational effectiveness and strategy, however, are influenced by location. In van den Bosch's [30 pp. 92-3) words, "firms create and attain superior and sustainable competitive positions over time **by their dynamic processes**".

Finally, it is suggested that management scholars engage themselves with dynamizing the applied construction-related chain of Porter's [4] frameworks so that managers in contracting, design, and product firms can ex ante formulate and implement **successful longitudinal business strategies in global construction markets** (a) by enhancing their understanding of a firm's initial internal and external conditions as well as their ability to make informed, successive true choices, (b) by formulating and implementing a set of cross-sectional strategies in innovative, integrative, and synergic ways, and (c) by learning to identify accidents or chances (or "luck") and evaluate their roles within different inputs, processes, causal relationships, and outcomes.

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Sustainable Construction for Countermeasure of Climate Change

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Abstract

There was quite big “Tsunami” around Sumatra Ireland of Indonesia at the end of 2005 hit on the coast of Thailand, Sri Lanka and Indonesia which caused quite big disaster to these countries. This is an example of global and natural disaster. Thus, one of the most important sustainable constructions should be making countermeasure for global problem. For instance by global warming, the sea water level will rise. This will be a potential of big disaster of shortage of food, especially in Asia where rice is major crop of food. If level of seawater rise, seawater will penetrate into paddy fields of rice production. Since rice plant cannot be grown in seawater, production of rice will be reduced. Therefore, it is necessary to do some counter measure for this as one of important items in sustainable construction. History told us that at the end of the Second World War, approximately one million people were died by the poor harvest of rice and bad administration by occupied military force of Japan in the region near to Hanoi, Viet Nam.

According to the report of IPCC (International Panel of Climate Change: 1995) there will be 5 major influences on the life of human being by climate change. Civil engineering should be responsible for solving this problem that effect on human being or life of human being by the global climate change. The National Research Council (NRC) Panel on Sea-Level Change projects a sea level rise of 50 cm ± 100 cm by the year 2100 (the assumed doubling time for CO_2). Major food crops in the world are wheat, rice and others. And distribution of the regions of production of these crops is depending on the geological and climate characteristics of lands. The production of rice is done mainly in Asian. Effects of rise of seawater level will be remarkably big on the agriculture. Especially effect on rice production is considered big, because rice is produced in the paddy field where water should be supplied from rivers or creeks near to sea. If sea water level will be rise, seawater will go to rivers or creeks to paddy field. Since rice can not grow in seawater, production of rice will go down remarkably. Actual way to prepare for rise of seawater level will be done by mainly two different systems. First is to avoid seawater to penetrate into river by some kind of wears and water gates. Another should be to make channel of water line along with shorelines to prevent penetration of seawater to paddy field near to coast with some protection of corrosion. However, these countermeasures cannot be done by one country because many rivers are international

rivers. International action and cooperation of the countries will be indispensable to prepare any countermeasure for these kinds of problem.

Keywords: Climate change, Rice production, sea water rise, water gate, channel

1. Introduction

According to the report of IPCC (International Panel of Climate Change:1995) there will be 5 major influences on the life of human being by climate change as follows: (1) Spreading out of the epidemic decease of tropical region like malaria. (2) There will be more typhoon, cyclone & hurricane. Location of rainy and dry region will be changed (3) Due to the rise of sea water level more erosion of land and penetration of sea-water to river. (4) There will be changes in species of forests. Rapid shrinking of forest and expand of deserts. (5) Fatal shortage of food will cause famine especially in least developed countries.

From view point of sustainable construction (2), (3) and (5) will be field of studies. Especially, civil engineering should be responsible for solving some problems that effect on human being or life of human being by the global climate change.

2. Climate Change and Rise of Sea Water Level

2.1 Predicting the Near Future

Is it possible to predict the characteristics of atmosphere in the future? Atmospheric scientists can, with reasonable confidence, forecast the patterns of the next few years, but their predictions become increasingly uncertain as they attempt to describe the more distant future. Numerical atmospheric models differ greatly in complexity, especially in their degree of spatial and temporal resolution. Ideally, a model should be able to generate predictions specific to large and small geographical areas and for long and short the intervals. In practice, though, the information required to do that may not be available, or the capabilities of the computers may be insufficient. All computer modelling efforts at best represent tradeoffs: scientists must choose spatial and temporal resolution at the expense of physical, chemical, and meteorological detail, or vice versa.

2.2 Global Warming Increase in Mean Sea Level

The possible global average temperature increase of one or two degrees centigrade over the next few decades may not sound very large until we compare it with past climate oscillations and consider what their effects have been. Generally speaking, computer models estimate that among the results of such warming would be an increase in global mean sea level of perhaps 20 cm by the Year 2030 and perhaps 45 cm by 2070. This will occur because the ocean water will expand slightly as it is heated and because a warmer climate will cause increased melting of mountain glaciers. Such sea level increases would produce major disruptions for the large fraction of the world's population living in coastal regions, especially the less developed nations in Southeast Asia. For example, in Bangladesh, most of the population lives at or near the water's edge. Finally, suppose that the higher-temperature warming scenarios occur, a prospect as likely as the lower ones. A change of 3° or more would be comparable to the temperature change that occurred between the last major ice age and the present, a transition that took place over several thousand years. In contrast, humankind would have produced, within a period of only a century, the warmest climate to exist in millions of years. We have only a vague idea of how our natural systems would respond. In addition to predicting how changes in the concentrations of today's greenhouse gases might affect future climates, it is worth asking whether other gases might be involved in future climate change

2.3 Projections or Future Sea Level Rise

The National Research Council (NRC) Panel on Sea-Level Change projects a sea level rise of 50 cm ± 100 cm by the year 2100 (the assumed doubling time for CO2). They assume a 3°to 6° global air temperature rise over the next hundred years based on results from general circulation models at NOAA's Geophysical Fluid Dynamics Laboratory, the National Centre for Atmospheric Research, and NASA's Goddard Space Centre. The thermal expansion part of this estimate is based on the work of Frei et al. (1988) who used two models for carrying heat down into and up out of the subsurface layers of the ocean, a pure diffusion model and an up welling-diffusion model. They project a 10 to 50 cm rise over the next century.

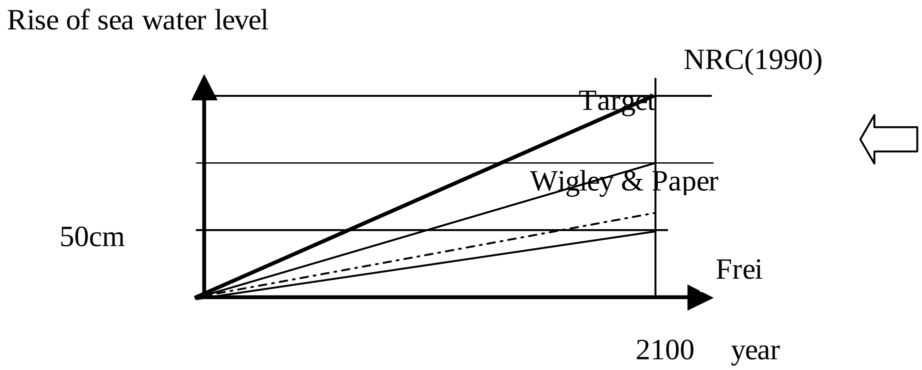


Figure 1: Estimated Amount of Rise of Sea Water Level.

For the contribution to sea level rise from ice wastage/melting the NRC panel used the results of the NRC Committee of Glaciology (NRC, 1985), whose "most likely" scenario was 55 cm ± 21 cm by the year 2100.

Warrick and Oerlemans (1990) (in the IPCC report on scientific assessment of climate change) project, for a "business as usual" scenario, a sea level rise of 21 to 71 cm by the year 2070, with a best estimate of 44 cm (66 cm for the year 2100). The thermal expansion part of this estimate is based on the upwe11ing-diffusion model of Wigley and Raper (1987), using projected global air temperature rises of l.5°, 2.5°, and 4.5° with the middle value considered a best estimate. They used the glacial contribution calculated by Raper et al. (1990) using a simple global glacial melt model, and they assumed no contribution from the Greenland or Antarctica ice sheets. Both these review papers also list projections by various researchers with "best estimates" ranging from 20 to 100 cm. There have been many estimation reports on the amount of rise of sea water level as shown in Fig.1.

Since estimation of seawater level rise is not decisively fixed, it is better here to consider as some condition to consider the amount of the sea water rise by the end of this century might be some around 100cm as a target.

3. Effect of Sea Level Rise on Rice Production

3.1 Rice as Major Crop in Southeast Asia

Major food crops in the world are wheat, rice and others. And distribution of the regions of production of these crops is depending on the geological and climate characteristics of lands. The production of rice is done mainly in Asian countries as shown in Figure 2 and Table 1. Total production of rice in the world is approx. 600 million tons/year. This amount is same as production of wheat.

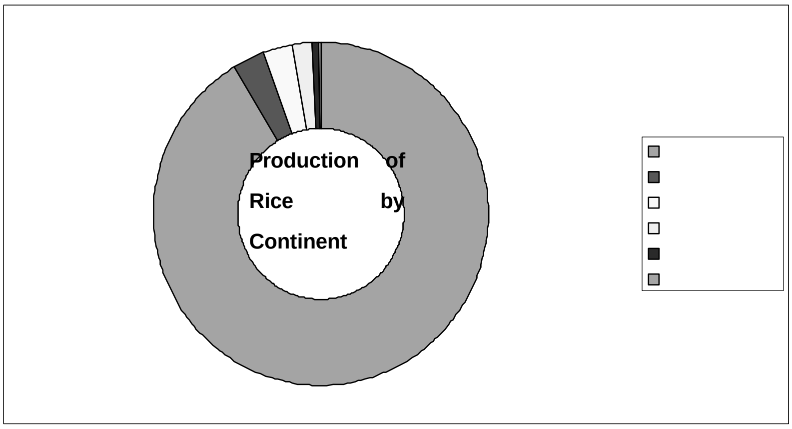


Figure 2: Production of Rice by Continent.

Therefore, the influence by rise of sea level on production of rice in Southeast Asia could be important to discuss the supply condition of rice in future**.**

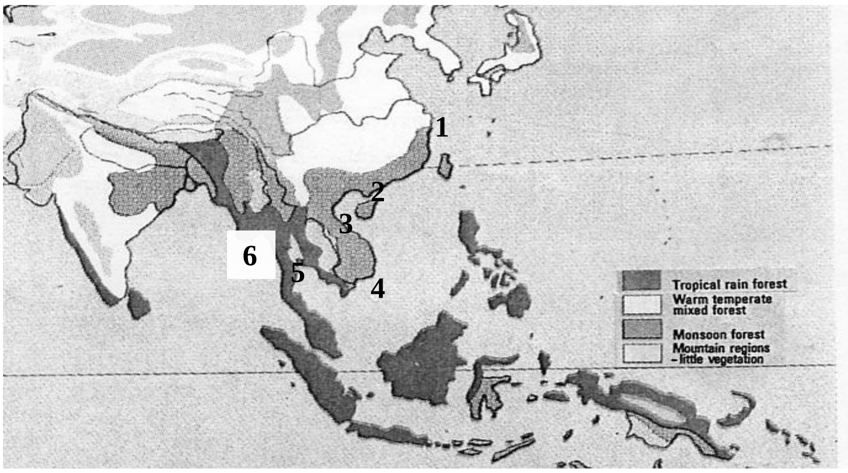
Table 1: Major Country of Rice Production.

	Country Name	Production in1,000tons	Percentage	
			export	to total
1	China	192,971	2.0	34.3
2	India	122,244	3.9	21.7
3	Indonesia	48,472	-3.9*	8.6
4	Vietnam	29,142	13.0	5.2
5	Bangladeshi	28,293	-4.0*	5.0
6	Thailand	23,240	27.3	4.1
7	Myanmar	16,651	----	3.0
8	Japan	11,200	3.2	2.0
	Total			83.9

Note: * show import

3.2 Effect of Rise of Seawater Level on Rice Production

Effects of rise of seawater level will be remarkably big on the agriculture. Especially effect on rice production is considered big, because rice is produced in the paddy field where water should be supplied from rivers or creeks near to sea. If sea water level will be rise, seawater will go to rivers or creeks to paddy field. Since rice cannot grow in seawater, production of rice will go down remarkably.



Names of rivers ; 1.Yellow River 2.Chang Jiang (Yangtze) 3.Hong 4.Mekong 5.Menam (Chao Phraya) 6.Ayeyarwady 7. Ganges

Figure 3: Chief Vegetation and Major Rivers with Large Deltas.

Since rice is major crop for food in the Southeast Asia where there are so many cases of damaged paddy field by penetration of seawater. Some of them became field for production of salt and other become pond for cultivation of shrimps. Figure.3 show the general vegetation in Southeast Asia and major rivers of the large deltas where paddy field of rice is concentrated.

3.3 Pioneer's Warning

One of the pioneer of this field of study, Lester Brown of World Watch, said that if climate change will going on and sea water level is going rise main region of rice production in Bangladesh will become under sea and serious shortage of food will hit not only Bangladesh but also whole region of Asia.

Also, king of Thailand took some measure to shift there major area of rice production from river mouth of Menam (Chao Phraya) to the north and East region of Thailand by development of facilities of irrigation .

4. Sustainable Construction as Countermeasure for Climate Change

4.1 Sustainability in Wide Sense

Sustainability usually implies that the use of energy and materials in an urban area be in balance with what the region can supply continuously through natural processes such as photosynthesis, biological decomposition and the biochemical processes that support life. Of course it is important and this concept of sustainability becomes common sense. But, this concept should be considered as narrow sense. It will be necessary to have some concept of wide sense such as making countermeasure for global problem like climate changes.

By doing so, many global problems should be studied to prepare necessary countermeasures.

To take the balance between developed countries and developing countries for execution of sustainability, developed countries should do sustainability in both wide and narrow sense and developing countries should do at least sustainability in narrow sense.

4.2 Search of General Systems for Countermeasure

Actual way to prepare for rise of seawater level will be done by different systems.

1. First is to avoid seawater to penetrate into river by some kind of wears and water gates.

2. Another should be to make channel of water line along with shorelines to prevent penetration of seawater to paddy field near to coast with some protection of corrosion.

There should be something unknown for countermeasure of rise of sea water level. In many regions some lands are under subject of flood. Floods may occur in rainy season and bring some fertile soil that will realize good harvest of rice. In these regions elevated floor of the house is common. In this region if sea water level will rise seawater will easily come to paddy field. It is difficult to conclude but some systems combination of 1 and 2 may be applicable.

4.3 Actual Construction of Some Systems of Counter Measure

Developing general systems of countermeasure, two systems as mentioned above have been required for further studies in details.

Wear and Water Gate Dam Construction System: In the case of wears and water gates in river mouths system should require the reinforcement of embankment for flood of the rivers. Therefore, types of wear and reinforcement of embankment should be planned not only for rise of sea water level but also conditions of flood. Also, there are many public objections to build the water gates and wears in river mouths because of division of river into two parts down stream and up stream which may cause the changes of environment in the region. Handling of these public objections should be studied and possibilities to apply “stakeholder management” which was quite effective at the cases of the projects of environment improvement in the city of Pittsburgh and was developed by University of Pittsburgh should be evaluated

Water Channel Along with Shoreline: These systems will be used area where there is not big river near by. But, due to the rise of sea water level land will be eroded seawater come to underground water to become seawater of paddy fields around. In that cases two major actions will be taken. One is shore protection against erosion of shore and another to provide fresh water by water-channels to the groundwater to replace seawater. These systems should be done as development scheme of the region. Some projects are going for almost same function in Japan in Tokushima area and another in Songkhla in south Thailand. However, these systems are should be taken into consideration with other infrastructure such as roads and bridges. Therefore, careful studies should be indispensable to plan them.

5. The Treatment of Risk

5.1 Inaccuracy in Estimation for Prediction

In the case of environmental problem, it is not possible to determine with certainty what result some particular policy of countermeasure will be, because scientific predictions by estimating are quite imprecise. Especially, it is significant that scientific uncertainty is afforded by the global-worming problem. Global worming could be trigger a rise in the sea level and result in destruction of plants including rice plants that could not be sited for the sea water to which they would to be subjected. The estimation that increased emission of carbon dioxide and other greenhouse gases are causing a rise in temperature is completely depending upon a computer model. This model itself has been partially validated. This is quite typical example showing the nature of problems. Thus the subject concerned to global climate changes is depending on the prediction in future. And there are so many kind of estimate. Since any countermeasure for the influence by climate change cost tremendously, more accurate prediction should be needed to be depending upon.

5.2 Environment Changes Caused by Counter Measure

Counter measures for climate change will cause another problem of changing environment such problems as in the Moses project in Venice for prevention of flood in S. Marco and construction of many dams located river mouth of Rhine near to Hoek Van Holland of Netherlands for storm surge barrier from the North Sea. These huge projects are considered to cause another big problem of change of environments of the regions that should be solved totally.

6. Implementation of Counter Measures

6.1 Importance of Earlier Start Up for Counter Measure

Since rise of sea water level by climate change already began it is necessary to start to do some counter measure to stop rise of sea water level as shown in Figure 4 below. In this connection it is quite good and big news that Kyoto protocol became effective recently.

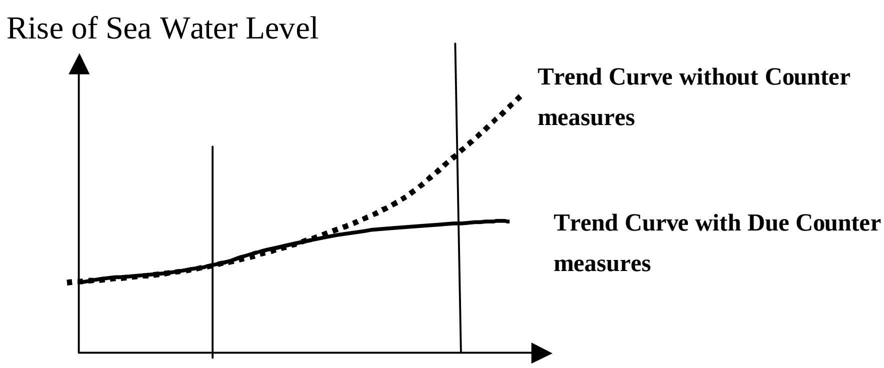


Figure 4: Rise of Sea Water Level and Counter Measure.

lso, even if rise of sea water level is going if there are any due counter measure to prevent penetration of sea water into paddy field production of rice can maintain necessary level as shown in Figure 5 below.

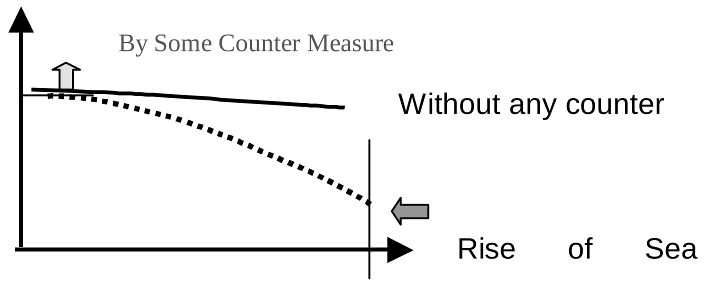


Figure 5: Rice Production and Counter Measure.

6.2 Required Integrating Frame Work

Any necessary counter measure cannot be done without making big integration since this problem has the global scale.

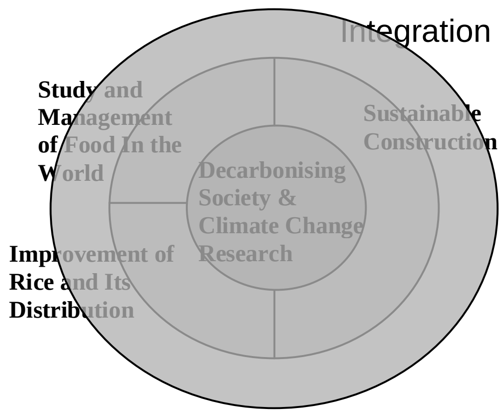


Figure 6: Integrating Frame Work

Even research work on this subject require some integration frame work like Tyndall Center, university of East Anglia, UK as shown in Figure 6 above. For this purpose Kyoto protocol made one step ahead to manage this global problem.

7. Conclusion

For sustainable development usually many studies have been mainly done for environment problems. One of the biggest possible disasters will be caused by rise of sea water level. Because rice plant cannot grow in seawater, there will be fatal poor harvest of rice to bring famine especially in Southeast Asia. However, problem is so big and complicated that global system approach by integration is needed to solve. This will be studied and executed by the people of the world because the sustainable development of Asia, economically, politically, and culturally, is one of the important issues that will be taking place in the world.

Throughout history of human being there has been endeavour effort to obtain enough food. However, by industrial revolution the productivity in agriculture industry has been jumped up. And surplus labour of countryside moves to city to obtain the job in manufacturing and service industry. Then transportation becomes more important. It can be said that previous 20century have been century of transportation and major infrastructure was facilities for transportation. By traffic and for manufacturing industries CO have been increased. This situation causes the warming of atmosphere to bring climate changes. Then, again there will be possibility for human being to be suffered from shortage of food. This disaster should be avoided by taking some countermeasure depending on the prediction by geophysics and meteorology. The prediction of environmental problems is not clear. Therefore, more flexible approaches will be necessary.

This problem should be preoccupation for people of Asia. People in rather developed countries in Asia study this and prepare some countermeasures together with people in developing countries. Also, this will be studied and executed by the people of the world because the sustainable development of Asia is, economically, politically, and culturally, one of the important issues that will be taking place in the world of Today. Therefore, this subject is not problem of people of Asia but one of the important issues of the people of the world. Then, more intensive and total study should be done by the people concern to avoid possible disaster which may be caused by this. Also process of the production of rice is so complicated and difficult in controlling water comparing with those of other grain that analyses should be done in close relationship with environmental issues.

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Improving International Construction Processes by Using Critical Incident Analysis

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Abstract

Due to a lot of developments on a worldwide but also local scale, construction industry is still an active area of business, e.g.: Life-cycle thinking in use and re-use of buildings, increasing need for better infrastructure, restoring demolished projects in post-disaster areas, etc. In several parts of the world one or more of these items are actual in the (local) economies. However, construction often plays quite a passive role in it, not being used as a driver but more as a tool for change or improvement.
This paper focusses on the role of construction industry in an international scope as an environment with existing critical incidents during the process, often leading to real conflicts. These critical incidents are exposed by the background, behaviour and expectations (e.g. culture) of the parties involved. This analysis shows there are a lot of specific individual situations and circumstances, being a threat as well as an opportunity for the 'running' and improvement of the process.
As part of the paper, the way how to learn from critical incidents in construction processes is described and discussed, especially in the way how they could be of use on a global (multi-cultural) scale, probably leading towards a useful 'set of tools' in the near future for improving construction processes locally. In fact the paper focusses on the issue of how to learn from experiences in construction, and how to generalize these experiences in such an (international) way, that one can take the advantage of it during the improvement (re-engineering) phase of construction processes. This, within the background of CIB-Taskgroup TG23, 'Culture in Construction', being established to be a 'platform' and 'driver' for exchanging experiences and knowledge worldwide, leading to a serious 'rethinking' of construction industry in the near future.

Keywords: *Change, Culture, Experiences, Learning, Re-engineering.*

1. Introduction

Modern construction industry relies heavily on human skills and craftsmanship. As construction still is a people's business, these issues are important drivers for keeping the delivered proces and product quality on the requested levels. However, clients do not always accept the delivered quality, as during the construction process several things can go wrong, e.g.:

- *Time-overrun;*
- *Cost-overrun;*
- *Lack of durability and/or sustainability;*
- *Disfunctioning of construction elements/products.*

In general, these failures do have their ‘roots’ in the contracts which lead to the delivered project. However, having a satisfying contract for both client and contractor is not only a matter of ‘writing’; it also and especially has to do with the fulfillment of expectations of the parties involved. This fulfillment needs a very careful proceeding of the initial stage of the construction process [22], focussing on exchange and documenting of the demands and needs of all the parties involved. Such an approach means that during this phase the final outcome of the total construction process will be influenced already within a certain way, as it is being influenced by culture (e.g. behaviour and expectations) of the parties involved during the whole construction process.
As the behaviour of parties in e.g. conflict situations often results into ‘litigation’ [7], serious attention has to be paid towards the process how information is being transformed by the several parties during construction. As part of this ‘transformation process’, e.g. for the construction environment described by Maas [12], the interaction between the parties involved is a key-issue for getting the demanded and/or the desired results. Therefore, it is important to understand the the clearly *exposed* information (e.g. written down in contracts), as well as the *hidden* information (e.g. shown by human behaviour and expectations). Thus:

- *The interaction (transformation) of both exposed and hidden information makes construction processes running.*

See figure 1 for the transformation-issue and it’s complications, combined with the behaviour and expectations of people, based on Maas [12].

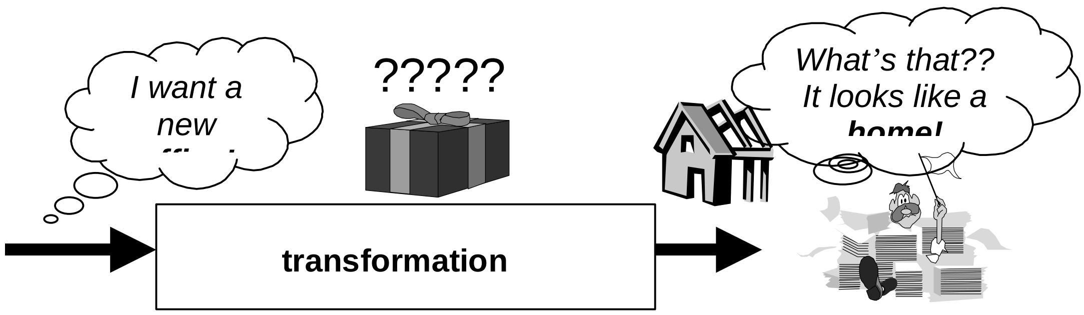

Figure 1: Transformation in construction and it’s complications: Not only a process of exposed information -e.g. contracts-, but also a process of hidden information -e.g. human behaviour and expectations-, based on Maas [12].

As the ‘real life’ behaviour and expectations of the parties involved plays an important role during construction processes, this paper analyzes some issues of the existing difficulties within cross-border construction projects. More specific, it focusses on the role which ‘learning from experiences’ plays durin striving for improving construction processes on a national and international scale.

Remarks:
It should be clear that daily practice in construction is a very interesting source of information for learning about the specific issues of construction processes. Also Geertz made it in clear from his viewpoint on research in general, when he stated [8]: ‘If you want to understand what a science is you should look in the firtst instance not at its theories or findings and certainly not at what its apologists say about it; you should look at what the practitioners of it do’.

2. Construction industry as ‘source of conflicts’: Threats or Opportunities?

In construction industry there are a lot of situations involving conflicts and its complications. This is obviously the case in several countries, as e.g. described and analyzed in the British market, Dutch market and German market, etc. [9][3][21]. However, failures and/or conflicts during construction processes are not only emerging since the last century. Also during ancient times this was an existing phenomenon. Think e.g. about the construction process of the Tower of Babylon, as described in the Holy Bible. The differences in language made it happen that the communication between the parties involved stopped, not understanding each other properly anymore. It lead in fact to the ‘internationalization’ of the world those days [19].
Since then, obviously hardly anything has changed: As in international construction processes also the role of communication is one of the most important one, the problem still exists, despite the present availability of state-of-the-art technology. Look e.g. at the information technology in general and the equipment available, e.g. being able to design for constructability [2][16]. However, when transforming the design into a ‘real life’ project, the production phase is still a difficult one with a lot of failures and risks as described in the introduction of this paper, although it also offering opportunities for new techologies [11].

More into detail, having modern technology available does not mean ‘automatically’ that the desired performance (e.g. in improving construction processes) is being reached. A systematic approach in learning from experiences -as discussed by Kerssens-Van Drongelen for measuring performance in an R&D environment- [10] may also be wished in the construction context, being able to handle the different behaviour and expectations of the parties involved. Especially, when one wants to control the ‘road’ on which obviously difficulties according to failures in procedures and/or products may turn into a real conflict.

As e.g. Felstiner, Abel & Sarat described, the raising of such conflicts often have to do with the background, behaviour and expectations (e.g. culture) of the people involved, leading to three different consequent phases of *naming*, *blaming* and *claiming* [6].

However, day to day practice shows that once within the ‘claiming’-phase, there is ‘no backroad’, whereas when being in the ‘naming’ or ‘blaming’-phase there often seems to be a ‘backroad’. However, this often has to do with the (un)willingness (e,.g. behaviour and expectations) of the parties involved. Figure 2 represents this schematically.

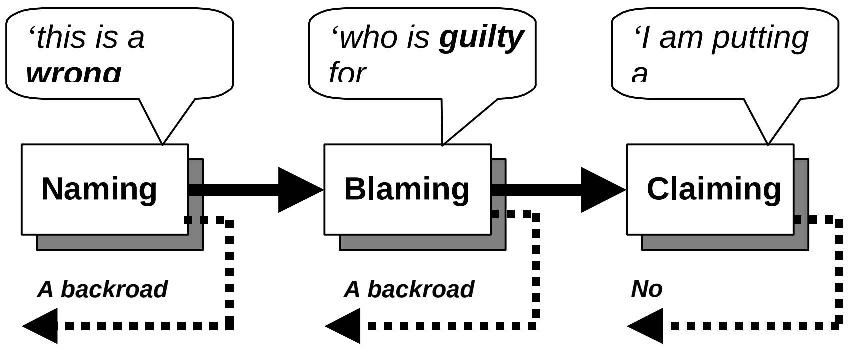

Figure 2: On the road to conflicts in construction, based on Felstiner, Abel & Sarat [6].

The above situation shows that especially during difficulties in construction, being or not real conflicts, the analysis of the behaviour and expectations of the people involved can be very useful for getting real-life information of the people’s culture. This information can be very useful for improving construction processes.
In our vision therefore, we see the raising of conflicts during construction mainly from two viewpoints, being as a threat as well as an opportunity:

- *Conflicts are <u>threatening</u> the smooth running of the construction process;*
- *Conflicts are an <u>opportunity</u> for getting real-life information in the field of culture (e.g. background, behaviour and expectations) of the parties involved.*

Both aspects of conflict-situations play an important role in construction processes. However, as this paper focusses mainly on learning from behaviour and expectations of the parties involved in construction, we consider the positive aspect of conflicts, using it as an *opportunity*.

3. Learning from Critical Incidents: A Mechanism of Change in Construction's Toolbox

While of course we don't strive for increasing conflicts in construction processes. As e.g. Moore describes, the existence of critical incidents ('conflicts') are not only a negative issue, but can be also and especially positive: Conflicts can be a 'driver' for organisations to change/adapt (improve!) their rules and regulations [13]. Describing process/project organizations as semi-autonomous social structures, this 'mechanism' will be influenced by the existing culture (e.g. being an easy or difficult changeable group of people, etc.). And especially these situations we analyse during our research activities on parties' behaviour within case-studies in construction industry.

So within this context of e.g. Moore's findings, the use of conflict-situations in researching behaviour and expectations of the parties involved in construction processes, is based on the following :

- *Critical indidents act as a 'driver for change' for the parties involved;*
- *Analyzing and understanding critical incidents can stimulate improvements (e.g. changes!) in construction processes.*

Figure 3 represents this approach schematically, showing the possible ways a construction-process often goes when getting into a conflict situation.

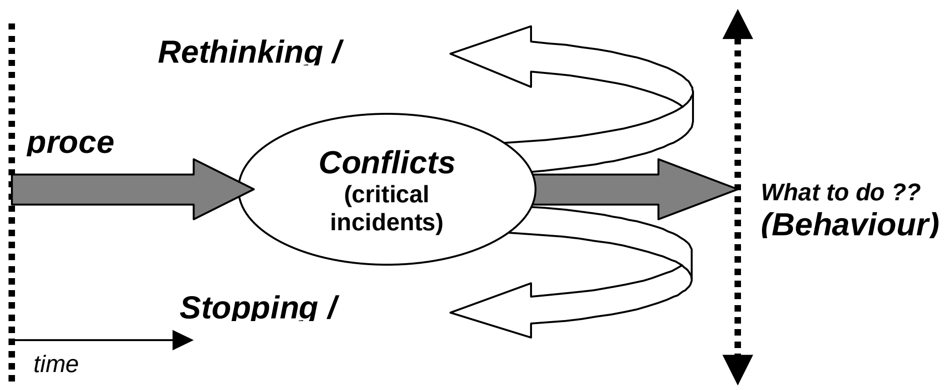

Figure 3: Analyzing and understanding critical incidents as a 'driver for change' is a valuable source of information for improving construction processes.

Using the critical incident approach, culture-research makes it possible to understand certain situations in construction process better, using this knowledge appropriately can stimulate the aspect of learning from practice. In addition to this, it can lead towards improving the construction process by overcoming 'barriers' in the process of changing construction. Ultimately the described approach really can help as a tool-box (e.g. 'driver') for changing present construction processes. However, insight into real-life projects is necessarily then.

4. Influences on learning from Critical Incidents: Being Inside and/or Outside the Practice

The focus on critical incidents is an interesting way of getting inside-experiences during construction processes. This, while there are obviously a lot of critical incidents in national as well as international construction, as highlighted in the previous part of this paper.
However, when using this approach in the (1) *collecting* and (2) *analysis* of data for reason of learning more into detail about people's behaviour and expectations in real-life construction processes, especially the following problems may occur:

1. *In collecting data: How to get the real data?;*
2. *In analysing data: How to prevent for interfering with the encountered situation?*

<u>Problem (1):</u>
There needs to be a real open access to the information-sources within the analyzed situation. Especially this is a problem, while generally it's difficult to have access into a 'running' organisation. As means of solving this problem, one can choose for a (partly)participative action research approach [18], being 'inside' the project-organisation, *'…to gain insight and understanding in the management of and interactions in work places'* [15].

<u>Problem (2):</u>
Participating within an organisation to describe and analyze real-life information and experiences cannot only be very useful in getting the right information, but it also incorporates a risk of getting influenced during e.g. collecting data, as one is still part of the analyzed process and/or project. Sanders is describing this as the aspect of *'being a third culture man'* [17], which he expresses as theres is a need of specific 'training' of the observing people involved when getting and analyzing the data. The observer should be the 'third culture' in processes, pointing at the fact that in general in a construction (conflict) situation there are often two parties involved (with often different cultures…).

Combining both problems (1) and (2) may lead to the following conclusions:

- *It's really important to have first-sight entrance in daily practice of projects. This means specific one needs good and open contacts with industry.*
- *However, one should continuously train oneself or being trained on the fact that one has to 'step back' regularly, reflecting the experiences during the encountered situations.*

When doing this properly, the reliability of collection and analysis of data will be much more improved.

5. Improving Construction on a Local Level within an International Scope

As investigations within theories and their experiences can differ between several situations and projects [20], the use and comparison of international experiences and their analysis is useful and necesseary for getting a more detailed view of practice within construction-processes/projects. Especially as construction industry in general is strongly related to its local context. Therefore a good and detailed view on the local practice is necessary for creating a good learning and/or training environment, especially when one wants to use such information for stimulating mechanisms of change for improving construction industry. Parallel to this, one should be aware that due to the fact construction is still a *people's business*, there will always we human *dynamics*, influencing these results. Within this context the following aspect is still important:

- *Learning from experiences is and will stay a dynamic issue in construction industry.*

And these dynamics are specifically present in international construction environments, as e.g. results from research, analysis and discussions within the CIB Task Group TG23 (Culture in Construction) also clearly emphasize: The importance of understanding local differences and backgrounds (e.g. cultures) are described in their recently published book on 'perspectives on culture in construction' [5]. Also in a book of another CIB Working Commission within, the CIB W107 (Construction in Developing Countries) this is emphasized, focussing on the need for training in developing areas; see e.g. Ogunlana [14].

In addition to the above publications, Erkelens pointed into detail at the need for improving productivity in 'self-help'-building activities in housing projects in developing regions [4]. Besides the often occurred theft of construction material in such areas (and not only in such areas but also e.g. in EU, etc….) the lack of labour quality skills was (and often still is) obviously a serious problem, leading to low quality results. Improvement of construction processes (e.g. productivity-level, etc.) in such situations therefore largely depends then on the level of training of the local employees within the context of their local circumstances & behaviour/culture.

Also Campion, Medsker and Higgs mention the 'productivity'-issue besides 'satisfaction' and 'managerial judgments' in their model of the effectiveness of work-groups [1]. This situation is comparable with the construction industry, where on national and international level employees often work in groups/teams and where also improvement of construction processes is e.g. related to the effectiveness of the employees involved.

Therefore, understanding the role of human behaviour and expectations in an international context or background should lead to the necessary information and insight for improving the training schemes for (local) employees. Moreover, while the employees are the *human capital* of construction companies and processes!

6. Discussion

Improving construction process will only be succesful when it takes into account seriously the possible barriers, especially those related to culture (e.g. background, behaviour and expectations). This, while improving construction practice on a serious level needs to be done by changing people, based on the assumption that construction is still a people's business. Therefore, improvement-efforts should not only focus on education and training of knowledge and skills, but also and especially by using experiences in tranferring such knowledge and skills, based e.g. on the behaviour and expectations (e.g. culture) of the group(s) of the employees. Analyzing and understanding this will be a valuable base for decreasing the possible barriers, improving the positive effects of training efforts. Not only on national but also on international level.
However, this may lead to the following discussion:

(a) *Can national ways of improving construction by education and training be 'internationalized' by using the added value of cultural data?*
(a) Are critical incidents a good and reliable source of information?
(b) Can a partly participative action approach give good and open access to the real practical data?

This discussion links with the theme of this paper, focussing on the issue of *how to learn from experiences in construction*, and *how to generalize these experiences* in such an (international) way, that one can take the advantage of it during the *improvement* (re-engineering) phase of construction processes.

7. Conclusions & Recommendations

(1) Focussing on critical incidents in national and international experiences in construction processes will give better chances for understanding (local) behaviour and expectations, while in critical incidents humans cannot 'hide' themselves without the risk of 'losing' their influences and/or positions in the process.

(2) Education and training in construction improvement processes will be more effective when they are based on the culture-aspects of the people involved.

(3) The use of experiences of 're-engineering' activities in developped areas are a valuable source of information for improvement activities in developping areas. Key issue then is a thourough documentation and analysis of 'real-life data', e.g. based on behavioural analysis during critical incidents in construction projects and processes.

(4) Whereas developing (or underdevelopped) regions will have in general a strong need for improvement of construction knowledge and skills during their development, the developped areas will have in general a strong need for (continuous) improvement by

re-engineering their processes. This can lead to a more or less cyclic (vice-versa) 'learning from practice'-approach on a global scale.

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Recursive Management of A Dynamic Business in Global Capital-Investment Markets

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Abstract

The selected principles of Beer's viable system model (VSM) are herein applied to the design of two recursive business-management concepts for managing a dynamic business as a system and its interaction with the targeted global capital-investment markets. Dynamism is perceived to include both static and dynamic businesses that firms find themselves in or (co-)create. (i) Along the organizational dimension, a global business is managed recursively as the first trio of viable systems: a corporation, its global business division, and organizational units (inside this division). The three degrees of highly, semi, and non-recursive global business (system) are defined for self-diagnosis purposes among interested managers. (ii) Along the temporal and cognitive-actionable dimensions, the scope of recursive global business management consists of the second trio: boundaries, models, and operations. The focal 2nd-order system involves the redesign of global business models. Its lower 1st-order recursion involves the same models-in-use, i.e. actually managing global business operations. Its higher 3rd-order recursion deals with the foresight and the boundary-setting issues that precede the business models over time. On an on-going basis, a global business (division) is managed recursively to attain the actual goals, its underlying business logic is being revised, and its boundaries are being reconsidered to anticipate and match major changes. It is proposed that a high degree of recursions is one of the necessary attributes of any concept that turns out to be effective in actually managing a global business.

Keywords: Business management, global construction markets, recursive systems

1. Introduction

Previously, the author has adopted Beer's [1] recursive principles and applied them to **re-conceptualizing the management of a firm** in terms of managing a firm's competitiveness as a set of three recursive competence-based systems [2], managing a firm in capital-investment markets [3], and managing a firm and its project-oriented businesses [4]. In turn, this fourth paper addresses the selected principles of recursive management and calibrates these further to advance business management in the focal context, i.e. capital-investment markets.

Why should one choose Beer's[1] [1] viable system model (VSM) as a frame of reference for approaching global business management? Objectivity implies that independent points of reference and school-free ways should be relied upon when one aims at avoiding major biases inherent in any of eight schools of thought in business management [5]. In many converging ways, systemic nature is, however, required in the cross-disciplinary literature. Several approaches to define an organization (e.g. a multinational corporation) as a dynamic system were identified within the systems literature (e.g. Checkland [6]). However, none concerns primarily the design of a global business-management system. So far, Beer's VSM is considered to fulfill best the need of determining a generic, systemic scope of global business management.

The purpose of this paper is (a) to introduce the wickedness of global business management in the context of capital-investment markets, (b) to apply the selected principles of Beer's viable system model (VSM) to the design of two recursive business-management concepts along the organizational dimension (the first concept) and along the temporal and cognitive-actionable recursive dimensions (the second concept), (c) to enhance the advancement of global business management among key senior scholars, (d) to inform about the further development of the two initial recursive concepts, and (e) to encourage interested global business managers to make a self-diagnosis of the current viability of their global business (divisions as recursive systems), respectively, and to proceed with strategic actions to achieve more sustainable viability in the future.

Global capital-investment markets deal with design, implementation, services, and life-cycle aspects of investments in the utilization of natural resources, energy supply, telecommunications, transportation, other infrastructure, manufacturing, and general building concerns. Capital investments (incl. construction investments) are herein perceived as a primary means to advance economic and social welfare in various countries across the globe.

Dynamism is perceived to include both static and dynamic businesses that firms find themselves in or (co-)create. Dynamism includes the total spectrum of managing a firm's business in static, dynamic, cyclical, hypercompetitive, and even chaotic markets. A population of firms operating in capital investment markets belongs primarily to **seven business-scope groups**: (i) technology-intensive contracting, (ii) construction-related contracting, (iii) process engineering, design, and consulting services, (iv) construction-related design and consulting services, (v) the supply of building products, systems, and materials, (vi) the supply of construction machinery, equipment, and tools as well as (vii) real estate ownership, development, management, and services [7 p. 100-102].

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[1] Stafford Beer died in August 2002

2. Wicked Global Business Problems vis-à-vis Management through Three Organizational Recursions

What is the sustainable, intriguing trigger of this paper (and the previous ones)? It lies inherent in the bold way that Rittel and Webber [8] deal with **wicked, planning problems** primarily in the societal context. They posit that governmental, political, or social problems are ill-defined and never solved. At best they are only re-solved – over and over again. They use the term wicked in a meaning akin to that of malignant (in contract to benign), or vicious (like a circle) or tricky or aggressive. In the same vein, it is argued herein that global business managers face frequently wicked problems, indeed. There are at least **ten distinguishing properties** of global business planning-types problems, i.e. wicked ones that managers had better be alert to such as a global business-management problem (i) cannot be formulated definitely, (ii) has no stopping rule, (iii) has only good-or-bad solutions (not true-or-false), (iv) is not testable with a potentially viable solution immediately or ultimately, (v) allows only one-shot-solutions (no opportunity to learn by trial-and-error because every attempt counts significantly), (vi) allows neither an enumerable (or exhaustingly describable) set of potential solutions, nor a well-described set of permissible operations that may be incorporated into a global business plan, (vii) is essentially unique, (viii) is a symptom of another problem, (ix) can be explained in numerous ways and, thus, the choice of explanation determines the nature of a problem's resolution, and (x) provides the global business manager with no right to be wrong (a manager is liable for the consequences of the decisions they make and those of the actions they generate).

In other words, a manager who is trying to manage her or his **open global business system** is caught in the ambiguity of its causal web, i.e. it defies efforts to delineate its boundaries and to identify the causes of most global business problems and thus to expose their more or less wicked nature. In turn, Beer [1 p. xiii] emphasizes that one of the main reasons why so many [global business] problems are intractable, is that they are formulated in such a way as to defeat any solution. Thus, many global business managers typically go on trying the solutions that have always failed to work in the past, instead of attempting to pose the business problems in a different and solvable way. In the case of China, there are multinational companies that fail to take advantage of local resources, preferring instead to stick to a global formula and running the risk of creating uneconomic cost structures. In some industries, the use of local equipment, design, and construction firms allows the Chinese to build factories and install machinery for just 30-50 % of what their foreign rivals would pay. Similarly, multinationals can benefit from China's unrivalled potential as a global sourcing center. General Electric, for example, has more than 300 purchasing agents in the country who certify suppliers for global sourcing. The company's stated goal was to have USD 5 billion in Chinese sales and to source USD 5 billion worth of products in China already in the year 2005 [9].

In turn, Beer [1 pp. 1-17] suggests that global business (and corporate) managers use his **Viable System Model (VSM)** to design and manage a viable business system, which can survive in its global environment. In particular, **recursiveness** is offered as one of the key principles of management for dealing successfully with wicked global business problems. In practice, the first plan is to consider a trio of viable systems at any one time along the organizational recursive dimension: one focal global business division (the 2nd-order system), the corporation within which it is contained (one level of recursion up, the 3rd-order system), and the set of organizational units contained and linked by this division (one level of recursion down, the 1st-order system). Herein, **the first business-management concept** is designed for managing a business (division) in global capital-investment markets as a recursive system with its basic attributes as follows:

- A full variety of the external states of a global capital-investment market type or a business type (based on capital investments) is allowed and the necessary and the sufficient conditions of success are redefined.

- Global business division co-defines its purpose and co-sets its goals (as governed by the corporate management).

- A network of globally-linked organizational units co-defines its integrated purpose and co-sets its goals (as guided by the global business management).

- All major parts (e.g. global business processes, operations, geographical units, profit centres, or competitiveness platforms) are designed as (sub)systems and their elements. At each level, all the subsystems and elements are coordinated and constrained for generating resource usage and synergy. Resources involve also all the core technologies, offerings, competences, and knowledge.

- (Self-)control between the three kinds of systems, i.e. the corporate management, the global business division, and its organizational parts is designed to enable both the cohesive management (top-down) and the actions of autonomous (sub-)systems (bottom-up).

- Market-related feedback loops are defined to allow pre-emptive, proactive, and reactive decisions and actions at each level.

- Each organizational unit is capable of responding to (un)known events that are likely to take the unit’s states and outcomes out of the targeted path.

It is proposed herein that **a high degree of organizational recursions** is one of the necessary attributes of any concept to be applicable for actually managing a global business successfully. Thus, the three degrees of a highly, semi, and non-recursive business management (system) are defined next in order to enable interested global business managers to proceed with the self-diagnosis of their current degrees of organizational recursions, respectively (Table 1).

Table 1: Three degrees of a recursive global business division (as a system) in the context of global capital-investment markets.

Degree	Systemic, recursive attributes of global business management
HIGHLY RECURSIVE BUSINESS SYSTEM	• A full variety of the external states of a market (business) type is allowed and the necessary and the sufficient conditions of success are redefined. • Global business division co-defines its purpose and co-sets its goals. • Each organizational unit co-defines its purpose and co-sets its goals. • All major parts are designed as (sub)systems. At each level, all the subsystems and elements are coordinated and constrained for generating resource (e.g. technologies, competences, knowledge) usage and synergy. • (Self-)control between the three systems is designed to enable both the cohesive management (top-down) and the actions of autonomous (sub-) system (bottom-up). • Market-related feedback loops are defined to allow pre-emptive, proactive, and reactive decisions and actions at each level. • Each unit is capable of responding to (un)known events that are likely to take the unit's states and outcomes out of the targeted path.
SEMI-RECURSIVE BUSINESS SYSTEM	• Only the typical external state(s) and conditions of success inherent in a market type (business type) are considered. • Global business division and/or its organizational units are not allowed to participate in defining the purposes or setting the goals for them. • Mistakes in articulating one of the three levels of recursion. • A designed attribute prevents the unit from acting as a recursive system. • One subsystem (part) is designed to show a predominant concern with its own interests rather than with the success of the division/unit as a whole. • Only the primary states (elements) are designed as sub-systems (constructs). • Interdependent relations are designed only between the primary elements. • Only one-level feedback loops are defined to allow reactive behavior.
NON-RECURSIVE BUSINESS SYSTEM	• No consideration of external states and the conditions of success inherent in a market type (business type) • Premises, purposes, and goals of a global business division are given. • Structure contains no recursive features. • Given attributes prevent the division from acting as a recursive system. • Many subsystems are designed to show a predominant concern with their own interests rather than with the success of the division as a whole. • States (elements) are defined as single entities, factors (or variables). • Only some or no interdependent relations are designed. • Only some or no feedback loops are defined.

3. Global Business Management through Temporal and Cognitive-Actionable Recursions

As Beer [1 p. 6] reminds managers, a global business (division) may have more than one next higher and next lower recursion. A recursion may deal both with an existing global business or the new one to be developed as well as their various states and stages. Herein, **the second**

business-management concept for managing a business in global capital-investment markets is first designed along the temporal recursive dimension. Thereafter, the initial concept is specified further along the cognitive-actionable recursive dimension as a set of three systems: global business boundaries, models, and operations vis-à-vis foreseen, desired, and targeted capital-investment markets.

3.1 Managing through Three Temporal Recursions

A global business system, its environment, and their interaction are herein defined in the context of capital-investment markets along the temporal dimension. In other words, **the scope of global business management** is defined on the 1st-order real-time plane, the 2nd-order design plane, and the 3rd-order foresight plane as follows (Figure 1):

§ System environment consists of (i) the well-known, globally targeted capital-investment markets with the conditions of success, (ii) desired future markets and the conditions of success, and (iii) the foreseen varieties of the same.

§ System-environment interaction consists of (i) the (non-)attained, targeted outcomes of the actual firm-market interaction in the global capital-investment markets, (ii) the desired outcomes of the planned firm-market interaction, and (iii) the foreseen varieties of the same.

§ First subsystem of a global business system consists of competitive elements: (i) re-executed ways of competing, competitive strategies, offerings, and client relationships, (ii) redesigned models of the same, and (iii) foreseen varieties of competition and competitive models.

§ Second subsystem of a global business system consists of operational elements: (i) releveraged ways of performing, competitive advantages, and global business processes, (ii) redesigned process models of the same, and (iii) foreseen varieties of global business operations and process models.

§ Third subsystem of a global business system consists of self-renewal, core elements: (i) ways of rebuilding the global competitiveness, e.g. core technologies, competences, and knowledge as well as their actual states, (ii) ways of redesigning the viable competitiveness and rebuilding models, and (iii) ways of foreseeing the varieties of competitiveness and related models.

Levels of recursion	Self-renewal, core elements	Operational elements	Competitive elements	Outcomes of firm-market interaction	Market type and conditions of success
Foreseeing global business boundaries (3^{rd}-order)	Foreseeing a variety of ways of redesigning global business models	Foreseeing a variety of viable ways of performing across the globe	Foreseeing a variety of viable ways of competing and interacting across the globe	Foreseeing a variety of outcomes of the foreseen firm-market interaction	Foreseeing a variety of capital investment markets and the conditions of success
Redesigning a global business system (2^{nd}-order)	Redesigning a global business system incl. competitiveness and ways of its rebuilding	Redesigning competitive advantages, processes, and ways of performing	Redesigning a competitive strategy with offerings and ways of executing	Retargeting the desired outcomes of the planned firm-market interaction	Retargeting the desired capital investment markets and the conditions of success
Managing a global business system (1^{st}-order)	Rebuilding the global business system incl. competitiveness continuously	Releveraging the competitive advantages and global business processes	Re-executing the global competitive strategies with the customized offerings	Attaining the targeted outcomes of the actual firm-market interaction	Knowing the targeted markets and the conditions of success and anticipating their changes

Figure 1: Scope of recursive global business management in terms of three systems (consisting of the systems themselves, the related global capital-investment markets as environments, and the outcomes of firm-market interaction).

3.2 Managing Global Business Operations (1^{st}-Order System)

It is proposed herein that **a firm's near-term global business success** can be managed in the targeted capital-investment markets, i.e. the global business-specific objectives and other targeted outcomes of the actual firm-market interaction are attained only by performing global business operations more effectively than global and local competitors do. In turn, superior operational effectiveness can be achieved through managing the 1^{st}-order subsystems in the integrated proactive ways: by knowing the attractive clients versus the strongest competitors with the global and local conditions of success and anticipating their changes as well as re-executing the competitive strategies and re-offering the best customized offerings to the targeted clients, releveraging the global and local business processes based on the competitive advantages, and rebuilding the elements of the global business (incl. competitiveness) system. All the 1^{st}-order elements need to be leveraged concurrently, which is illustrated in Figure 2.

In particular, a firm's near-term success requires that global business operations management is competent enough to close **global and local performance gaps**, i.e. major differences between the desired states of the 1^{st}-order subsystems leading towards the objective-attainment and the actual, predicted, or anticipated states under conduct. Performance-gap closing takes place through reactive and proactive actions in the contexts of on-going global and local operations and contracts. Herein, Beer's [1 p. 9] notion on managing **high stability** (homeostasis) inside a global business division (and its organizational units), despite the division having to cope with unpredictable global capital-investment markets, appears to be one of the prerequisites for the objective-attainment.

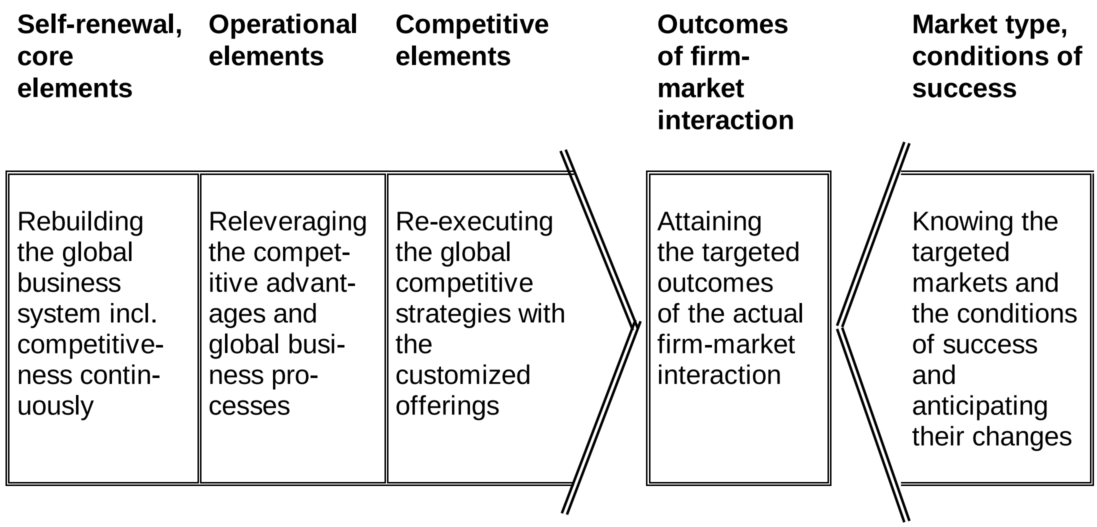

Figure 2: Managing global business operations (as the 1st-order system) in the targeted global capital-investment markets.

It is proposed herein that **a firm's global long-term competitiveness** can be ensured in the desired capital-investment markets ex ante, i.e. the global business goals and the other desired outcomes of future firm-market interaction will be attained only by redesigning better global business (incl. competitiveness) models than the anticipated global and local competitors will do. In turn, superior global business models will be redesigned through managing the 2^{nd}-order subsystems in increasingly networked ways: by retargeting the most desired capital-investment markets according to changing conditions of creating value networks and capturing the best value both for the clients and other networked stakeholders as well as redesigning the anticipated set of competitive, offering, advantage, process, business system, and competitiveness models. All these 2^{nd}-order elements need to be redesigned concurrently, which is illustrated in Figure 3.

In particular, a firm's long-term competitiveness requires that global business models management is competent enough to close **global and local competitiveness gaps**, i.e. differences between the desired states of the 2^{nd}-order subsystems leading towards the goal-attainment and the designed, predicted, or anticipated states of the desired capital-investment markets with the conditions of success and those of a set of global business models. On a design plane, competitiveness-gap closing takes place through proactive redesigns of the existing and new global business models in the context of the focal global business as well as its desired markets and stakeholders. Herein, Beer's [1 p. 17] notion of incorporating **a minimum set of invariants** into global business models appears to be one of the prerequisites for high global competitiveness. Invariants such as core technologies, core competences, and tacit knowledge are unaffected by most of changes surrounding them.

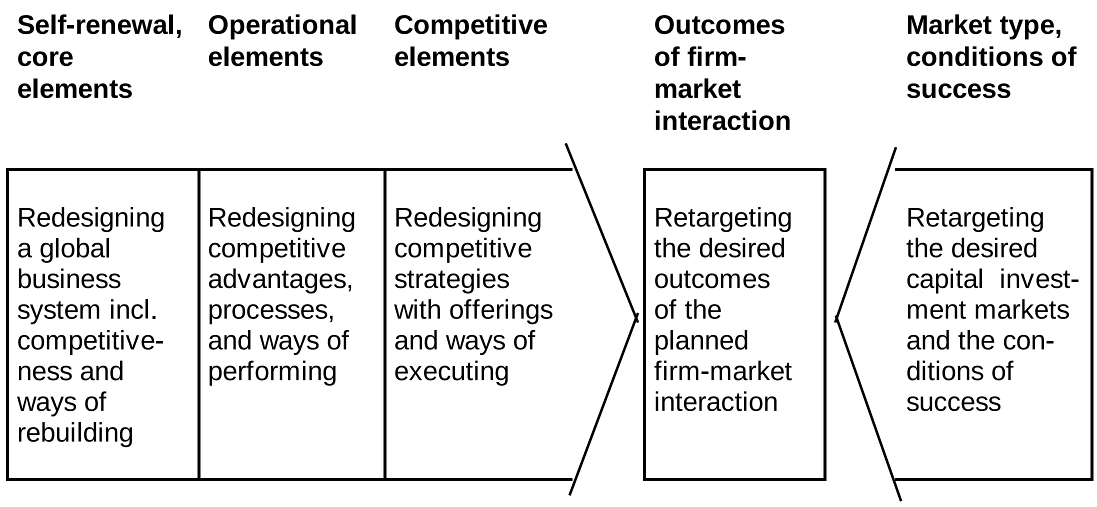

Figure 3: Redesigning global business and competitiveness models (as the 2nd-order focal system) for planned operations in the desired global investment markets.

3.3 Foreseeing Global Business Boundaries (3rd-Order System)

It is proposed herein that **the existence of a global business (division)** can be sustained within the plausible variety of future capital-investment markets ex ante, i.e. the existential business goals and many other positive outcomes of the firm-market interaction will be attained only by foreseeing each of these five interrelated varieties before and even in more new future business-creating ways than any of (non-)expected competitors will do. In turn, the sustainable existence of the global business division will be foreseen and re-created through managing the 3rd-order boundary-setting subsystems: by making tradeoffs in choosing (and not choosing) to invest in supporting or creating the desired variety and types of future capital-investment markets as well as in advancing the known ways and/or creating the new ways of competing with global and local competitors, caring global and local clients, performing the business processes across the globe as well as redesigning and rebuilding the various (non-)existing global business and competitiveness models. All these 3rd-order elements need to be foreseen and addressed concurrently, which is illustrated in Figure 4.

In particular, the existence of a global business (division) requires that global business boundaries management is competent enough to close **global and local boundary gaps**, i.e. differences between the desired states of the 3rd-order subsystems leading towards the sustained existence and the foreseen varieties of both the future capital-investment markets with the conditions of success and a set of future models. Boundary-gap closing takes place through managing the foreseen varieties of future global markets, business models, and competitiveness. Herein, **the application of Ashby's law** [1 p. 35] seems to be one of the prerequisites for the sustained existence, i.e. future operation, model, and market varieties should be foreseen, coupled, and designed to equate to maximal extents and with minimal damages to future competitiveness and success.

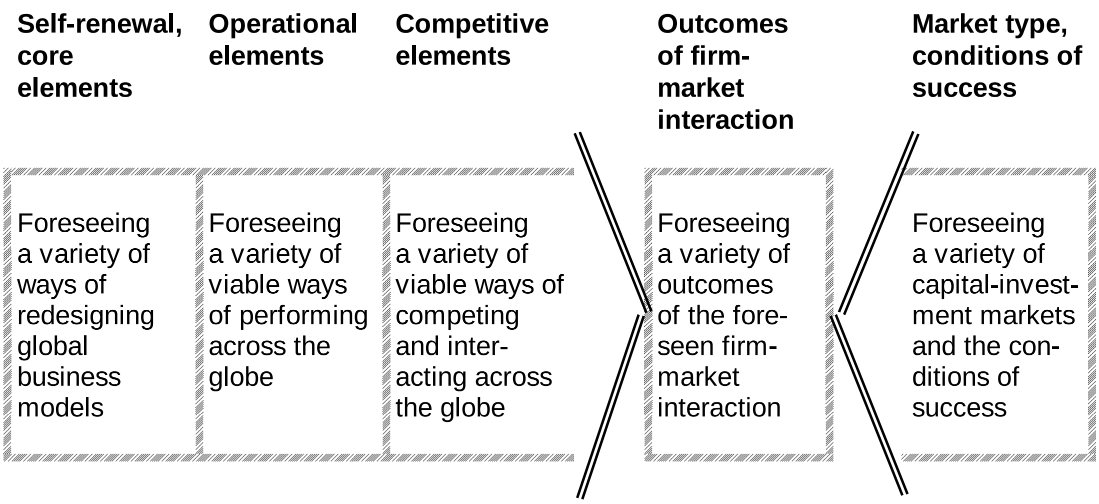

Figure 4: Foreseeing the varieties of business boundaries (as the 3rd-order system) for the three viable business systems in the context of conditioned global capital-investment markets.

4. Conclusions

Previously, the author has also exposed that no established tradition exists in construction-related business-management research [5, 10]. The identified population consists of 38 business-management concepts published between the years 1990-2002. Moreover, many of these concepts are not directly applicable to actually managing a dynamic business in global capital (including construction) investment markets. Thus, it is repeated herein that the key senior scholars within the four related fields of engineering sciences, i.e. construction economics and management, real estate management, project management, and industrial management would develop new effective global business-management concepts in the future.

In turn, this paper is part of the on-going study on new recursive and competence-based ways of managing firms and their businesses successfully in global capital-investment markets. Next, the author will define and incorporate a firm’s competences in global business management into the two recursive business-management concepts. The two generic concepts will be calibrated to match particularities inherent in global capital-investment markets. Thereafter, the applicability of the calibrated concepts to managing a dynamic business in global capital-investment markets will be tested among the selected Finland-based firms. Finally, the guidelines and the prerequisites for the adoption of any recursive, competence-based concept among practicing global business managers will be specified in detail.

In the meantime, each interested global business manager is encouraged to start with the initial self-diagnosis of the viability of her or his global business as a trio of (a) recursive organizational systems, (b) recursive temporal systems, and/or (c) recursive cognitive-actionable systems. The purpose of this diagnosis is to assess the current degrees of the enabling recursions inside the existing global business (division, i.e. three systems) and to proceed with foreseeing its future boundaries and redesigning the division accordingly in order to survive in desired global capital-investment markets.

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A Step Forward to Improve the Japanese Construction Supervisor by Introducing Toyota Production System

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Abstract

This paper analyses the differences between management and conformation to get the final products by introducing TOYOTA Production System (TPS). As the result of it, we can make it clear that Kouji-Kanri (Supervision or Inspection) in Japan is limited for "fitness for purpose". Furthermore, Kouji-Kanri has the similar function as Construction Manager in the US, Clerk of Works in the UK from the viewpoint of their business objectives. The difference between management and confirmation in construction projects is whether information process management or quality confirmation by checking products.

The Japanese construction industry has been focused on not customer side but supply side like productivity increase of construction projects. This paper shows that the changing definition of Japanese Kouji-Kanri produces management procurement system, which is based on client's objectives and the nature of projects; furthermore, it has come to introduce new management style of the Japanese construction projects as Construction Conformation.

Keywords: Construction Management, Construction Supervisor, Project Management, Quality Control

1. Introduction

Three elements in a quality determination process, which constitute a construction project, are TIME, COST, and QUALITY. It is said that the element, which determines the quality especially in construction phase, is applied to design quality and the construction quality based on the design drawings. Verification between design drawings and execution is important. In Japan, the construction supervision person who is defined by the Japanese architectural law could carry out this verification procedure. As for construction supervision business in Japan, the management itself is not necessarily defined by this meaning. However, it is also the fact that various management is carried out, and furthermore, management business does not remain in construction phase, but management carried out in a series of product processes from the planning phase of the project to the completion phase of construction. On the other hand, in Toyota, the product process was made into "the chain of quality" and it has succeeded for users, to achieve expected performances and the acceleration nature of a car and manoeuvrability drivability, and amenity, a style, raising all the value expected to a car. Fujimoto and others have indicated especially (2001) in car manufacturing that the heavyweight project manager who carries out proper management existed in a project. Moreover, in management, both Design Quality and Conformance Quality were raised and high Total Product Quality comes true. Accordingly, this paper shows the characteristics of the Japanese construction supervision by comparative study in construction projects among Japan, China, Korea, the UK, and the US on "the chain of quality" of Toyota.

2. The Concept of Quality

2.1 What Are Products?

Fujimoto (2000) explains that the process of the Toyota production system can be defined as "Informational exchange". That is, one product is defined as "Goods" which added information to the material.

"Product = Information (Design) + Material"

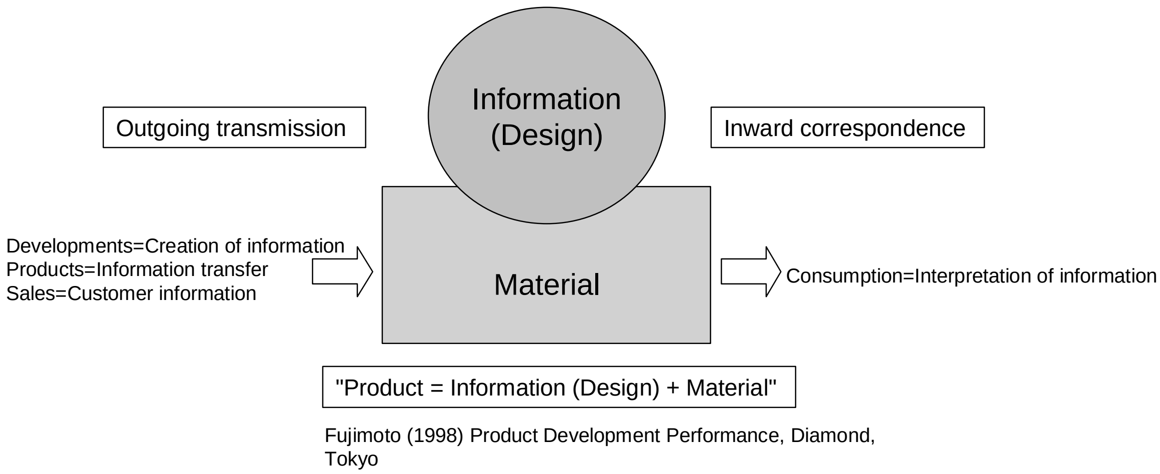

Figure 1: The definition of Products.

Product activity can be defined by the following the product process such as information source, information flow, and information modification.

2.2 Definition of Quality

Fujimoto (2001) is introducing the following elements, in order to define quality.

- Performance
- Reliability
- Conformance
- Durability
- Serviceability
- Aesthetics
- Features
- Perceived Quality

These concepts are named generically as "Total Product Quality" (TPQ).

As mentioned before, TPQ is defined as the degree of the customer satisfaction (CS)) which the product itself gives to a user. Furthermore, TPQ is roughly divided into two elements. They are “Design Quality” and “Conformance Quality”. Design Quality is the function of product and the product meant, a performance, appearance, etc. in the design phase process, and Design Quality is "the quality aimed at as the target of manufacture", or "the product function which the customer was promised beforehand." On the other hand, Conformance Quality shows whether the product in user’s purchase phase realizes original intent of customers such as function and appearance, etc. of design phase. That is "the chain of quality” which combined these two types’ quality concepts.

In the chain of quality, upstream of the flow services (customer needs => product concept => product basic design => product detailed design) comprise “Design Quality”, and downstream of the flow services (product detailed design => process design => process => product) are “Conformance Quality”.

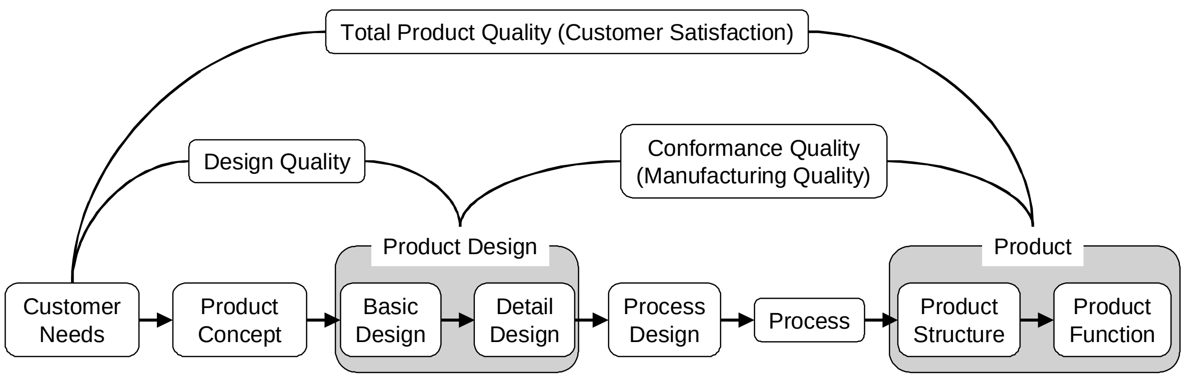

Figure 2: Product Process in Manufacturing Industry.

2.3 The Difference between Toyota Production System (TPS) and Construction Product Process

In a construction project, the design activity for keeping quality is extended into construction phase after design phase activities. On the other hand, the automobile design as Toyota Production System (TPS) in "the chain of quality" is finished completely in design phase. For example, in Japanese construction projects, the actual condition is carried out not in design phases, such as color of materials, and determination of settlement, but in the construction phase. It is, therefore, conformance check and management are needed for each product phase in construction projects in order to secure TPQ.

3. International Comparison of the Construction Management Business in Quality Control

In this chapter, the management of construction supervision business is compared by fitness for purpose. The role of construction supervision is not only checking the fitness for purpose between design drawings and construction progress, but also manage between client requirements and construction process by schedule control, coordination among contractors and so on. The construction supervision is reconstructing by introducing the relation between “information” and “products”. The relationship between “information” and “products” is not remaining within the scope of business services in construction supervision, but it is crossed to the whole project. It is therefore necessary to make clear definition in the construction product process.

3.1 Analysis in Deliverables of Construction Projects

Figure 3 shows the process of construction projects notionally. It is common to grasp as combination of phase like design phase and order phase in construction projects.

Since the management business was defined as IDEF (Input and output relation), it is decided to analyze deliverables in each phase, such as client requirements, design information, product information, middle products and final products. That is, the deliverables of preceding phase serves as Input for the deliverables of the following phase. The business activities in each phase are developed based on the Input element. According to the relation of two phases’ deliverables, each activity is classified into two types activities, one is management and the other is fitness for purpose as conformance. The management activities are defined as assembly between information and products.

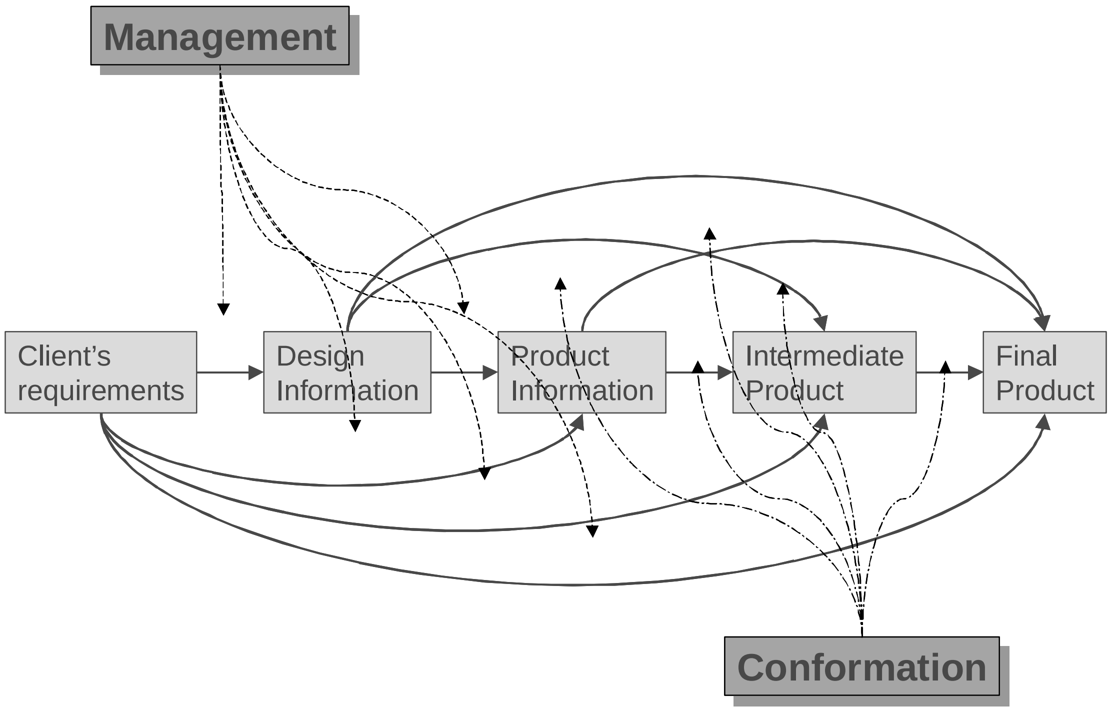

Figure 3: Product Process in Construction Projects.

3.2 Comparison of Management and Fitness for Purpose

Table 4 summarizes the enforcement person of "management business" and "fitness for purpose" as international comparison based on the law and contract clause of each country of the process of Fig. 3. The contents of Table 4 show the operating number of Fig. 3. The UK definition is specified as business of "designer" based on Services Supplement (business classification) of Standard Form of Agreement of RIBA. In Japan, the business which has the possibility been done by CMr shows additional activities in the table.

3.3 The Case in Japan as No CM System

All management activities have been done by Architects or Design Units except for "Management Request for Proposal (RFP) for Construction from Design". In Japan and China, it is difficult to specify the enforcement person of management business, and only the Republic of Korea that has introduced CM system makes much management business to CMr. The conformance check has been mainly done by construction supervisors and supervisor units, but in Japan, "Activity of conformance of client's requirements & final product" is recognized as architects' duty. On the other hand, although "Activity of Conformance of design & final product" is recognized as construction supervisor's business in Korea, CMr carries out all other conformance activities of design information and products. As the result of it, the activities of construction supervisor are limited to only conformance between design drawings and products, which are narrow definition rather than that of Japan and China.

3.4 The Case in Japan as CM System

In the case of introducing CMr as project participants, the following management and conformance activities are defined as CM activities, which are "Management RFP for Construction from Design", "Management Product information based on client's requirements", "Management intermediate product information based on client's requirements", "Conformance of Product Information & final product", and "Conformance of client's requirements & final product".

3.5 Outline

As a whole, the coverage of management businesses in Japan and China is mainly indefinite. On the other hand, the countries such as Korea by which CMr is defined by regulation and contract are that the role of construction supervisor is limited only to conformance between design drawings and products.

The main activities in construction supervisor and relief man of supervisor such as CMr and supervisor unit in China are mainly conformance between design drawings and intermediate products and final products. In the case of existing CMr, CMr has managed all activities from the viewpoint of client's requirements.

These analyses establish the existence of conformance and management process in construction product process. It is necessary in Japan to make clear construction supervisor's responsibility and activities in order to introduce international definition of conformance and management, which are confused in the Japanese projects. It is also important to analyze each construction supervisor's activity to split for conformance activity and management activity from now on.

Table 1: International comparison about "who does what".

Activity	Japan	USA	UK	China	Korea
I) The assembly of information and products (= "Management" activities)					
Management Client's requirements	Architect (CMr (No. 113))	CMr Architect (B141-4.2)	Architect CMr (JCT 1.1)	Architectural Unit	Architect (1.2.1)
Management REP for Design from Brief	Architect	Architect (B141-2.1.1)	Architect	Architectural Unit	Architect (1.2.1)
Management RFP for Construction from Design	Contractor (CMr (510))	Contractor (A201-3.12.5)	Architect CMr (JCT 8.2)	Supervise Unit	CMr (Guideline)
Management Product information based on client's requirements	Architect (CMr (517))	CMr (A201-4.6.11)	Architect CMr (JCT 9.1)	Architectural Unit	Architect (1.2.1)
Management intermediate product information based on client's requirements	Architect	CMr (A201-4.6.11)	Architect CMr (JCT 8.6)	Architectural Unit	Architect (1.2.1)
Management final product information based on client's requirements	Architect	CMr (A201-4.6.11)	Architect CMr (JCT 11.4)	Architectural Unit	Architect (1.2.1)
II) The conformance check of information and products (= "Conformance" activities)					
Conformance of Product Information & intermediate product	Construction Supervisor	CMr (A201-4.6.2)	CMr (JCT 11.4)	Supervise Unit	CMr (Guideline)
Conformance of Product Information & final product	Construction Supervisor (CMr (518))	CMr (A201-4.6.2)	CMr (JCT 11.4)	Supervise Unit	CMr (Guideline)
Conformance of client's requirements & final product	Architect (CMr (519))	---	CMr (JCT 11.4)	Architectural Unit	CMr (Guideline)
Conformance of design & intermediate product	Construction Supervisor	CMr (A201-4.6.2)	Architect Clerk of Works (3.11)	Architectural Unit	Construction Supervisor (19)
Conformance of design & final product	Construction Supervisor	CMr (A201-4.6.2)	Architect Clerk of Works (3.11)	Architectural Unit	Construction Supervisor (19)
Conformance of Product Information & final product	Construction Supervisor	CMr (A201-4.6.2)	CMr (JCT 11.4) Clerk of Works (3.09)	Supervise Unit	CMr (Guideline)

CMr and Architect have done management activities. Construction Supervisor, CMr, and Supervise Unit are carrying out conformance activities. Since CMr is not defined in China, it is classified into design and supervision, it turns out that an architect mainly carries out management activities, and a construction supervisor is carrying out conformance activities. Conformance activities in Korea are done by CMr whose activities are originally architects and construction supervisors. The construction volume of CM at Risk procurement is increasing in

Korea, but market share is little because of pure CM is much popular rather than CM at Risk. CMr has some more responsibility to keep certain level's quality. It is as follows when each role is clarified based on these international comparisons.

(1) The role of Construction Supervisor.

A construction supervisor carries out the conformance check of design information and products (included intermediate products), which is defined by the notification No. 1206 of the Japanese Architectural Law.

(2) The role of CMr.

CMr mainly carries out management business in construction phase. While design information has been indefinite in construction phase, it can be extracted possible design information, performing control with the intermediate products and indefinite design information by CMr's management services.

That is, CMr is carrying out "management of design information and final products". In this meaning, the business of CMr has some analogy to the business of Construction Supervisor.

CMr can carry out management business not only in construction phase but also in planning phase and design phase. On the other hand, Construction supervisor's business is only limited in construction phase.

The role of CMr in the Republic of Korea is expected not only in construction phase but also in design phase. In this case, the main function of CMr is client's agent and bridge person between a client and other project's participants. CMr is mainly carrying out management of a client and the others, and conformance check of the client's project requirements and products. CMr is also taking in charge the adjustment business between an architect and a construction supervisor. There are also many examples called PMr instead of CMr as client's agent in wider sense.

(3) The role of Architect.

It is the main business for an architect to adjust the client's requirements as design information. However, the definition of design information in construction industry is quite different from that of manufacturing industry. Design information of the construction industry has not completed in design phase. The design has been continuous even in construction phase, and design information has been modified by intermediate products. It is, therefore, difficult to forecast product's quality after design phase in construction industry.

4. Conclusion

The Japanese construction supervisor is defined by the Japanese architectural law, whose notification No. 1206 defined a construction supervisor as conformance check of design drawings and products. The business of Japanese construction supervisor is similar to CMr in the US and clerk of works in the UK.

The role of the Construction Supervisor in quality control of the Japanese projects is crucial as conformance of design information and products. But, types of projects are at present diversified, so that many cased of hiring CMr are increasing.

Therefore, CMr and construction supervisor's business is re-defined as quality control, and it is required to show the new construction supervision business's in various construction projects with various client's choices and selection in Japan.

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International Comparative Study on Construction Management through the Spread Process

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Abstract

Construction Management (CM) first began about 20 years ago in Japan, and has been spreading since then. Every country needs a different style of Construction Management Service. This study aims to clarify the differences in styles through a comparison of the spread process of Construction Management in Japan, the US, and Singapore. The motives for introducing Construction Management in each of these three countries were learned through a survey which will be explained, along with a description of the spread process of Construction Management.

Keywords: Construction Management, Construction Manager, Building Construction System, Project Management, International Project

1. Introduction

1.1 Background of Research and Purpose

The Construction Management (CM) system is a building project implementation system, which has been spreading throughout the world in recent years. In Japan, it has been carried out on a daily basis for about 20 years. However, there are two kinds of management needed as CM service, one is common to all countries which have CM, and the other is a management style customized by each country. The movement toward internationalization of construction projects and international entry by construction firms into each other's business spheres has been expanding recently. It is, therefore, meaningful to clarify the differences between CM systems in one’s own country and in foreign countries.

The following four points of CM systems in different countries will be addressed:

- Description of the spread process of CM system of each country

- Definition the difference of purpose for adopting CM systems to a construction project in each country

- Clarification of the difference of types of CM systems due to the differences in construction production systems in each country

- Prediction of deployment of future CM systems in each of the three countries, based on the knowledge acquired through the above three topics

1.2 The Method of Research

The countries for comparison are Japan, the United States, and Singapore. The US produced the first CM system. Singapore was selected for this study, because many Japanese construction companies are very active in that market.

1.3 The Features of the Research

This research is arranged as a comparison of the similarities in each of the three CM systems. We refer to each part of a CM system as a subsystem.

Many problems related to internationalization in recent years have been solved as a whole, because of fundamental research done for the purpose of encouraging rational internationalization.

The motives for the introduction of CM systems in the three countries are analyzed in this study. The reasons are clarified by describing the Spread Process under each of the CM systems.

2. Spread Process of CM System in Japan

In Japan, although introduction of CM was considered in the 1970s, it was abandoned due to the difficulty that clients had in making contracts directly with subcontractors. General contractors at that time considered their service as a kind of CM service. As the result, the CM system was not introduced until the 1990s.

2.1 Introduction of CM System

Below are some reasons for the introduction of the CM system in the 1990s:

- The Japan Institute of Architects (JIA) conducted basic research to determine the satisfaction level of clients. JIA found that many clients wanted to change the procurement system from the traditional way to the CM system.

Clients were dissatisfied with:

§ Cost related services

- § Project Management related services
- § Aftercare services

Many clients were dissatisfied with architects' cost management, especially in the early stages of construction projects.

Clients also had issues with general contractors, so they strongly wanted to introduce the CM system into their projects in order to create cost transparency. Today, CM guidelines issued by the Ministry of Land, Infrastructure and Transport (MLIT) mention that the highest merits of the CM system are transparency of construction costs.

Table 1: Why clients were interested in the CM system ? (by MLIT).

- § Transparency of costs
- § Transparency of procurement process, such as subcontractor's selection procedure
- § Realization of fair value
- § Quality assurance
- § High level of client involvement

Table 2:Some points proposed by JIA for reform in the Japanese construction production system.

- § Transparency of construction costs
- § Clarification of responsibility and authority in connection with construction process

2.2 Some Examples of CM Systems

Table 3 shows some examples of the current CM system in Japan. There are many examples of what increases transparency and cost cuts, such as separate orders and cost on contracts. Moreover, many cases improve traditional management style by transforming management to create high transparency and rationalization. Rationalization produces a variety of procurement routes. Table 3 also shows a few examples which enhance management in the briefing and in the planning phases. It is said that, because of the CM system in Japan there are few incidents where architects are requested to solve such problems. Japanese clients often request to have an independent construction manager as a representative on the project.

2.3 The Objective of the Introduction of CM System

The motive of the introduction of CM was clients' dissatisfaction with the lack of cost control in the early stages of the construction phase and lack of cost transparency.

Table 3: Example of CM technique in Japan.

	Examples of CM
1	CM service at early stage from briefing phase to basic design phase
2	CMr estimates construction costs and selects special contractors instead of KEIRETSU of a general contractor. This method improves cost transparency even hiring a general contractor. CMr also adopts Value Engineering technique by changing order.
3	Ban of bid-rigging by declaration by contractors Precedence order of steel frame The opacity of price and cost over-run is eliminated.
4	CMr decides temporary management.
5	Client has selected special contractors that contract to general contractor by negotiating with client, architect, general contractor and CMr.
6	Client determines subcontractors and they contract with a principal contractor. The role of CMr is limited as cost, quality and time management in construction phase. Large budget exaggerated-in the middle of project.
7	Three equipment works are ordered by separate contracts as cost-on with a general contractor. The general contractor and sub-contractors are selected by CMr with client, and if possible, the CMr has the authority to change sub-contractors from the companies which are recommended by the general contractor to nominated contractors with negotiation. It is the fact that 117 works have been changed.
8	Client has ordered building works to a general contractor and 10 special works to special contractors. CMr contributes evaluation of contractors' ability. Moreover, CMr performed risk management and reserved contingency.
9	Client concludes contract with a general contractor as a lump sum. CMr has the responsibility to control all participants as substitute of the client. The client's requirements to CMr are to keep transparency and accountability into the project.
10	Client orders five types' works, building work, electrical work, air-Conditioning and plumbing work, elevator work and machine parking work. The client has contracted 8 special contractors as cost on contract. The company, which conducts building work, controls all total management. PMr is substitute for client and verified procurement by client.
11	Special contractors have carried out 16 separated orders, and a general contractor conducts main works. Design has been developed by master designer, show & presentation designer, shop architect, and building architect in isolation. CMr makes suggestions about facilities planning.
12	The project divides into six construction works which include building work. CMr is also an architect. Client is very aggressive and his requirement is to control all project phase in the shadow of support by CMR in the field of procurement process, cost comparative research and QCDS.
13	Equipment works and special construction works are separated and each work is cost-on contract (General construction works, safety responsibility and temporary work are included). CMr is representative of client, and CMR has responsibility to control project budget, schedule control, etc.

Table 4: Determination of project promotion organization.

	CMR selection	Work responsibility	Contractor selection	Procurement selection	Organization
2			CMr & Client talks		
6			Client	Client	CMr & Contractor talks
7			Client selects 5 nominated contractor. CMr squeezes 3 preferred contractors. Client, finally, selects best preferable contractor as the result of interview.		
8			CMr		CMr
9	Nominated	Depends on responsibility assignment	Nominated	Client & CMR talks	Client
10		Based on contract documents, etc.	Negotiation		
11	Nominated	Contract documents	1 Cost 2 Technology 3 others 4 Credit Nominated bidder	CMr	CMr
12	Nominated	Responsibility assignment	Nominated by cost	Client	CMr
13	QBS	Contract documents	Nominated by cost	Client	Client & CMr talks

3. Spread Process of CM in the US

2.4 The Objective of the Introduction of CM System

The CM system in the US was introduced as an alternative of the conventional traditional procurement process (Traditional Approach) from the second half of the 1960s, to the first half of the 1970s.

The flow of the CM system is summarized as follows:

First, social change, such as hyperinflation and large-scale construction projects were phenomena in the 1960's. Therefore, the traditional system fell out of favour as a result, and the CM system was introduced to address these problems. Table 5 shows a comparative study between traditional procurement and CM procurement in the US. Many clients in those days expressed a strong desire for phased construction in order to shorten completion times.

Table 5: Weak points of traditional procurement and strong points of CM

	Weakness of traditional procurement	Strength of CM
1	Delay by continuous (sequential)	Shrinking duration by phased construction
2	The plan, the design, and supervision without reflecting builder's opinion	Introduction of the builder knowledge in design phase
3	The hostility relation by the disagreement of the profits between client and general contractor	Combination and integration (team approach) among members

2.5 The First CM System, in the 1970s

In the US, the government (GSA: General Service Administration) adopted the CM system for their construction projects in the early 1970s. It was not effective, so the use of CM was abandoned in 1979. Because the Project Manager (PMr) of GSA had strong power, lack of authority of CMr was cited as the reason for discontinuing the CM system. It was scheduled to be revived after 1983, when the number of GSA employees was drastically decreased, and it was necessary to hire consultants from outside of government.

2.6 Characteristics of CM Market

The Characteristics of the CM market based on an analysis of the Engineering News Record are as follows:

§ Total volume of CM service has been increasing

§ Competition has become very severe, because entities outside of the building industry are entering the CM market

§ Other procurement such as Design Build procurement has emerged and has become popular.

The CMr usually leads the whole project, instead of the client. The client usually assembles the construction team by himself, with the intention of insuring good relationships between the client and the subcontractors and among the subcontractors themselves. The client's efforts in this area are all done with the support of the CM system.

2.7 Historical Background of CM

From the second half of the 1960s to the first half of the 1970s, CM was introduced to overcome the flaws of traditional procurement. However, nowadays Design Build procurement has been increasing. Since there are a lot of risks such as law suits and labour disputes in certain areas (e.g. New York) where the unions are strong, CM has become increasingly important for maintaining good relations between contractors and labour unions.

3. Spread Process of CM System in Singapore

The motive for introducing the CM system in Singapore was taken from studies of individual projects as examples. In Singapore, CM is mostly restricted to special projects, such as pharmaceutical and oil refineries. The term CMr is used instead of PMr. The role of CMr is as a third opinion on projects. Also, the client relies on the CMr as an independent consultant.

3.1 The Main Features of Construction industry in Singapore

The big problem in the Singaporean construction industry is that there are many foreign workers who are, generally speaking, not well trained and often do not speak the local language, causing many problems.

3.2 Project Example

The W project in 1986, carried out under the CM system, had a complicated organization form, and the client wished to have a strong involvement in order to insure quality work. (As shown in Figure 1) There was strong participation from the client side to maintain quality.

Moreover, foreign workers were hired for the W project; they accounted for 85% or more of the number of employees, and 50% of the materials for the projects were from overseas. Therefore, management of labour and materials was crucial.

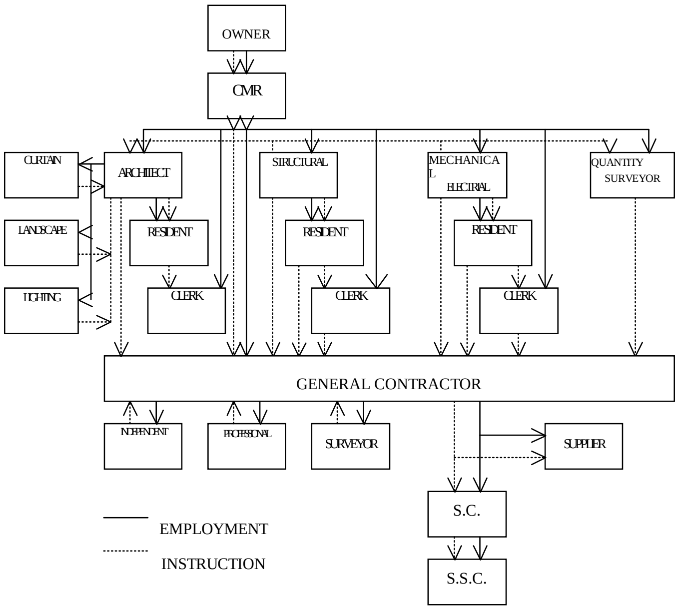

Figure 1: Organizational structure of W project

3.3 Consideration of an Introductory Motives

In Singapore, quality control is of the utmost importance, because of their high dependence on such a large number of foreign workers and imported materials. Quality control services are usually performed by the client. It is complicated for the client as there so many subcontractors are causing a huge number of adjustments and changes to be made by each subcontractor. For those reasons, CMr are usually hired by the client to ease their burden.

4. Comparison of Defining of CM in Each Country in Spread Process

4.1 Japan

In Japan, the dissatisfaction of clients with the construction industry in the 1990s became the driving force for introduction of the CM system. Clients were dissatisfied with contractors, because of the lack of cost transparency. They were also frustrated with architects, because of their lack of cost management and procurement skills. The CM system has alleviated all of these problems for the client.

From the briefing phase to the design phase, the CM evaluates the project in respect to cost, and proceeds with a transparency for everyone who enters into a contractor with the client. When construction actually begins, the CMr insures transparency, and rationality, quality control and fairness.

4.2 The US

In the US, the disadvantages of traditional procurement between the 1960s and the 1970s were as follows:

- Delays were very frequent and lengthy
- The design was often difficult to actually construct, as the general contractors had no input to the architect
- Clients complained to general contractors that they overcharged

CMr were hired to solve these problems. CMr also diffuse hostilities between clients and labour unions.

The CM system resolves issues between the client and the subcontractors, as well as among the subcontractors themselves.

4.3 Singapore

In Singapore, within their huge dependence on foreign workers and materials, CMr are almost a necessity with so many problems arising due to the low skill level of many workers, and because of varying standards of imported materials.

Thus, a clear difference exists for the reasons for the introduction of the CM systems in Japan, the US, and Singapore. These differences necessitate differences in the way, CM systems are used in the three countries.

CMr conduct appropriate risk management tasks, such as hiring, preventive measures related to the quality of work and the quality of imported materials.

5. Conclusions

From the spread process of the CM system in Japan, the US, and Singapore, this research determined the motives for the introduction of the CM system in the three countries and it compares these systems. The motives are different for each respective countries and the style of each CM system differs according to countries. However, our research only addressed the contrasting reasons and aspects;

There are many similarities as far as the reasons for these three countries implementing the CM system and how they use it, but they have not been mentioned here. They were not the subjects of this research. The authors intend to do further research in order to closely examine their similarities, which was the next purpose of this research.

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Section III

Performance of the AEC sector

International Project-level Comparisons of Construction Industry Performance

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Abstract

This paper reports on further investigations into comparisons of the performance of the construction industries in various countries. It builds on earlier work that analysed construction time, cost and quality data gathered for high rise office building projects in a number of countries and sought to use that data to make valid comparisons of industry performance at the level of individual projects. The previous work produced a simple "performance index" that could be used to compare construction performance across projects. That index is examined in more detail with particular emphasis on the conversion of construction costs from national currencies to a common base.

Keywords: Construction industry performance, international comparisons, purchasing power parity, Big Mac Index.

1. Introduction

The construction industries in various countries contribute greatly to national economies – gross construction output in the period 1945-1990 in North America and Western Europe averaged somewhere between 12% and 15% of GDP [1]. In OECD countries generally the contribution ranges between 5% and 8% [2]. Construction is a key element in investment, and to the future prosperity of nations [3]. It is important that the sector operates with maximum efficiency [4] and that scarce resources are utilised in the best possible way.

Given the importance of construction in measures of national output it is not surprising that many stakeholders are interested in measuring how effective the activities of the construction sector are. This has become increasingly so as national construction industries have sought to expand into international markets [5]. Comparative studies have been attempted since at least the late 1940s [6] and many different methodologies have been used, with varying degrees of success.

This paper reviews some of the more recent attempts at international comparisons and compares them to a Performance Index (PI) proposed by Langston and Best [7]. In particular the paper focuses on the problems of gathering suitable data (time, cost and quality) and the major problem of converting construction costs to a common base.

2. Comparative Studies

Any sort of comparative study has a number of inherent problems, the most common are described as “comparability and representivity” – simply, the comparing of like with like but using data that is representative of typical practice in different places. With construction these problems are particularly severe as output (buildings, bridges, roads and the like) are seldom, if ever, identical. When international comparisons are attempted these problems are exacerbated, as there is no truly “standard” project that can be used a basis for comparison, however, comparisons are made and do produce some useful insights (e.g. [8, 9, 10, 11, 12]).

The studies have approached international comparisons in many different ways including those based purely on construction cost [13, 14], or labour productivity [15], those using input-output analysis [16], and other macroeconomic data [17] and some that have attempted to analyse and explain differences across a broader range of factors in the whole process of building procurement [7]. These studies have been categorised as pricing studies, macroeconomic studies and case studies [18]. A few have characteristics of more than one type.

2.1 Comparative Methods

Pricing studies compare construction costs between countries, typically on the basis of a standard project (or set of projects). The problems of comparability and representivity of the projects are always evident, and in any case equating industry performance or competitiveness on the basis of cost alone is surely problematic, as apparently lower local construction costs do not mean that the same industry building in another country (and subject to that country’s laws, regulations, labour market and so on) could build for the same cost that it does at home [18]. There is even greater concern when costs are converted from local currency to some common base (usually US$). In one study [19] the authors assessed Australia’s construction costs as second lowest and Germany most expensive (in a field of five) but they had converted costs using money market exchange rates, and commented that “it would appear that Australia with its *currency exchange advantage* is more competitive” [emphasis added]. Using different methods (discussed below) the same cost data was used by Langston and de Valence [14] - they ranked Germany least expensive, and Australia most expensive. This illustrates just how sensitive these studies are to the methods used for cost conversion.

Macroeconomic studies are generally based on a single input, usually labour. Typical measures include value added per employee or hour worked, or construction volume per employee or hour worked. Many authors are critical of this approach, and question its usefulness for a variety of reasons claiming it to be too simple to be an adequate measure of overall productivity in an economic sector as large and complex as construction [20]; cost effective but with suspect reliability and comparability of data [21]; too lacking in detail to be of use below the whole-of-industry level [9]; an unsatisfactory measure of efficiency of utilisation of resources [22] and noting its to reflect differences in capital intensity in measures such as output per hour worked or per person employed [23]; or to provide data on quality [24].

Croce *et al.* [3] list a series of reasons why labour productivity is an unreliable measure, including, amongst other things, distortions that emerge when construction times are shortened (and, as a result, costs decrease), thus appearing to decrease output when measured in dollars, as is typically done. They also mention changes in composition of activity (e.g. residential versus non-residential construction) that see increased activity in the residential sector, which typically has lower productivity than the non-residential sector, giving the appearance that overall productivity has levelled out or even declined. Although they repeatedly question the reliability of macroeconomic studies, the authors use labour productivity figures to conclude that labour productivity in Australia "is above that for the US, Japan and all European nations". They rely on similar analyses of construction costs to conclude that "Australia is more than competitive with other western countries". On the basis of their analysis, their conclusions about Australia's performance must be questioned.

Case studies provide useful insights into why there are differences in performance between countries, but they, too, have their drawbacks. They are labour-intensive and are consequently reduced to just a few projects, perhaps as few as two, e.g [25, 8], and while the projects may be quite comparable it is always doubtful that they can be representative of the whole industry in a country.

Some studies are hybrids. Langston and Best [7] gathered project data for 78 high rise office projects across 12 countries. Costs were converted using several methods, including the Big Mac index (see below at 4.4) and relationships between factors such as resource consumption (cost/m^2) and productivity (m^2/month) were tested. From this a Performance Index (PI) was proposed, which was expressed as a ration of productivity to resource consumption. Simple algebra reduced this expression to a ratio of the square of the building area to cost multiplied by time to construct:

$$\text{Performance Index (PI)} = \frac{a^2}{ct} \qquad \text{(Equation 1)}$$

where a is the area in m^2, c is cost (in a common currency) and t is time to construct (in months). The higher the index, the better the performance.

Xiao and Proverbs [10, 11 12] carried out a more comprehensive study of contractor performance in the UK, the US and Japan. They sought data on various aspects of time, cost and quality performance. They used a standard project but tried to improve representivity (while maintaining comparability) by providing only a verbal description of the project and leaving respondents to provide estimates based on construction methods and materials typical of their region. This study has some similarities with previous pricing studies but it goes far beyond cost alone. The methodology, however, is not necessarily as successful as they claim as they draw very definite conclusions about industry performance in the countries studied based on estimates alone (of construction time and cost particularly) of a hypothetical and loosely defined project, and include some very questionable data (e.g. estimated construction times ranging from an unlikely 12 weeks up to a glacial 108 weeks for the same "standard" project). They convert estimated construction costs to £UK using OECD purchasing power parities (PPPs – see below at 4), which is reasonable, but when slightly more recent PPPs are used the outcomes change dramatically with the ranking of the UK and Japan (based on average cost/m^2) reversed, with the cost in Japan changing from around 5% *less* than the UK to nearly 12% *above* that in the UK. The outcomes of such studies must always be treated with care, and this again highlights the importance of valid currency conversions.

3. The Theory of the Performance Index

While previous studies focused on one or two aspects of performance (e.g. cost or time), performance has four aspects: productivity, time, cost and quality, and any measure of performance should embrace all of them [26]. The two studies described above do, to some extent, include all four, although measuring quality remains a difficulty. Productivity can be measured at an industry level (using macroeconomic data) or at a micro level (individual trades or onsite tasks), however, time, cost and quality are best measured at a project level. The Performance Index proposed by Langston and Best [7] includes a measure of productivity and makes this approach very useful as it assesses, to some degree, all aspects of performance at the level of individual projects. If data for a large enough number of projects can be obtained then the sample should be reasonably representative of the industry as a whole.

Productivity is typically expressed as the ratio of inputs to outputs – units of construction output can be expressed as m^2 of floor space. Inputs to the construction are many and varied, and different inputs may be measured in different units: number of people, items of plant, quantities of materials and so on. The only available common unit, however, is money, so factors of production (inputs) are most conveniently expressed in dollars. The rate of resource use may therefore be expressed as "construction \$/month". Hence productivity can be expressed as the ratio of output (m^2 of floor area/month) to inputs (resource use expressed as \$/m^2).

The performance index is defined as $\dfrac{productivity}{resource\ use}$ or $\dfrac{m^2/month}{cost/m^2}$

which equals $\dfrac{m^2 \,.\, m^2}{cost \,.\, month}$ or $\dfrac{a^2}{ct}$ (see Equation 1)

Cost/m^2 is obviously influenced by quality standards, i.e. a higher quality output may simply reflect higher quality inputs (such as prestige materials or fittings) so some adjustment to cost is needed to address quality differences. The simplest way is to separate projects into quality groups, e.g. for offices the typical groupings are Prestige, Grade A, B, C and D [27]; alternatively indices can be calculated that deflate costs to a common standard. Other aspects of quality, such as client satisfaction, are less easily accommodated but can be measured if data is available. Current UK KPIs [28] include measures of defects, predictability of cost and time as well as client satisfaction (with both product and process), so this sort of data is now being gathered.

One of the strengths of the PI is that it uses actual data from completed projects rather than estimates based on hypothetical projects. Total cost and time to construct, for example, will include at least some part of any extra money and/or time required to correct defects or carry out rework – contractors would be going out of business more often than they do if these penalties were not included. Costs are best stated exclusive of substructure and siteworks as cost and time associated with these elements can vary markedly between projects purely due to the scope of the work [29]. Projects should be of one type or grouped according to type (as well as quality) and analysed separately – this will improve comparability.

4. Currency Conversions

Converting costs to a common currency using exchange rates only, is a method now generally recognised as flawed [30, 13, 31, 32, 33]. The aim must be to eliminate, as far as possible, differences in prices between countries so that when costs are converted to a common currency they are then valued at the same price levels [34]. This is commonly done using purchasing power parities (PPPs). While PPPs are widely used for a variety of purposes they are not necessarily appropriate in all cases, and the use of general PPPs for industry-level productivity comparisons is not recommended [33]. Stapel [35] also advises against their use in a number of circumstances, including their use "as a measure to generate output and productivity comparisons by industry (unless there are industry specific PPPs)". To date few, if any, reliable industry-specific PPPs have been published.

4.1 The Law of One Price

Purchasing power parities are based on the so-called Law of One Price [36, 37]. The basis of this is the notion that the cost of a good or service (or a basket of goods and services), once prices are converted to a common currency, should cost the same in different countries [38]. For some commodities that are traded often, such as gold, the law of one price holds well [38]. It does not hold for construction output [13] as built facilities are not tradeable [33], and are produced and consumed locally. A large proportion of the cost of a building is made up of labour costs and basic materials such as bricks, sand and concrete. These are mostly produced locally rather than imported and therefore their costs are little affected by exchange rates [13].

4.2 Calculating Purchasing Power Parities

A range of PPPs are routinely produced. General PPPs are the result of extensive price gathering exercises carried out by Eurostat and the OECD, part of the International Comparison Program (ICP) for the UN and World Bank [39] The OECD's 1996 comparison used a list of around 4000 items including consumer goods and services, pharmaceutical products, capital goods, motor vehicles, government services, health and education services, and twenty construction projects [39]. Construction prices were gathered by having comprehensive bills of quantities (BQs) priced by estimators in participating countries. This system has been under review for some years as there are serious doubts about the reliability of results [40, 41] and the level of effort and resources required to gather the data [42, 29, 43]. The ICP method is also under review, with a new framework for collecting construction data about to be tested [39].

4.3 Construction Data for PPPs

In the Eurostat program the amount of data collected for construction has been reduced by around 50% in recent rounds [29]. Fewer projects are being priced and the BQs for those projects that are priced have been abbreviated. Meikle [45, 41] advocates a move away from the BQ approach to a weighted basket of goods (BOG) approach. The aim is to make pricing easier and more reliable, and improve the comparability and representivity of the data collected.

The ICP, however, are to trial a method proposed by Walsh and Sawhney [39, 44], using a basket of construction components (BOCC). A pilot study is to be run in 2005 that will also include multiple pricing of some simple inputs (steel and cement) as well as components such as structural concrete columns, simple pad footings and cement render [44]. These input items will be priced at various locations several times each year in a bid to minimise temporal and regional differences. As the ICP includes many more countries than the Eurostat/OECD group (186 countries rather than around 35) the problems of comparability and representivity are multiplied. The key to success in using this approach lies in identifying and specifying a basket of components that are reasonably similar in composition and construction in all countries. It remains to be seen whether a large enough basket can be assembled to allow estimated prices to be meaningful. Meikle [45, 41] suggests that the approach is flawed, as the pricing of the BOCC will lack context (e.g. scale, location, site conditions, access). It can be argued, however, that the perceived lack of context does not necessarily invalidate the concept, as most of these concerns can be shown to be of relatively little consequence. The fact that the best estimates routinely vary by as much as ±10% when compared to outturn costs, supports this view as the sort of cost differences that arise through contextual variations are likely to be insignificant within such an estimate band.

Stapel [29] suggests that “the principal determinants of price level [in construction] are probably scale, complexity and location rather than the type of work”. Meikle [45] is quite definite about it. The two-stage study completed in Australia in 1999 [19, 14] supports the view that the type of project has little impact on cost differentials. Based on that research Langston and Best [7] limited their study to a single building type (high rise commercial offices) as this was considered to be the most “generic” building type common to all the countries in their study.

It could be argued that even with the use of detailed BQs the issue of scale may not be addressed. Meikle [45] shows that the projects currently priced in the Eurostat/OECD program do not properly represent the typical mix of projects (with regard to scale) usually built. He demonstrates that the hypothetical projects priced in the UK are generally unrepresentative of the size range of projects actually constructed. Furthermore it is doubtful that estimators would apply a level of care that would include pricing differently for projects of varying scale; there is no incentive to price as low as possible in order to win the job, and the estimators can be sure that their companies will not have to build to their estimated cost [46]

Location (geographically speaking) can be addressed as it is now, by asking estimators to give national average prices, or by having estimates produces in several locations within a country. This could be done regardless of whether it is a basket of goods, a basket of components or a set of standard projects that is being priced. Location, (within projects, i.e. ground floor, 10th floor, 50th floor) has some impact on prices but it is common practice for many levels of multi-storey projects to be measured and priced together, particularly in countries such as Australia where there has been a definite move towards “concise” BQs. Hoisting and scaffolding costs will affect unit rates for work at elevation but given that labour and materials generally make up the greater proportion of unit rates, and prices gathered are estimates of national averages, price distortions due to the inclusion or exclusion of within-project location in pricing exercises would be unlikely to vary beyond the normal limits of estimating accuracy. If overheads are spread within prices then fixed crane and hoist charges are likely to be embedded in unit rates anyway.

Stapel’s third determinant, complexity, is more difficult to accommodate but as it is “average” prices that are generally sought, the effects of complexity of construction on some projects can arguably be discounted. Once again it is unlikely that estimates will vary beyond normally accepted limits of estimating accuracy.

If context is indeed a problem with the BOCC method then it is likely to be even more of a concern in a BOG approach. While scale may be addressed by asking for prices for differing quantities of the same item (e.g. 100m3, 10,000m3, 100,000m3 of excavation in other than rock) location and complexity would appear to be impossible to deal without providing very detailed contextual information with every item in the basket. Such information would be very hard to convey accurately and the outcomes would be no more or less reliable than those gained using other methods. Meikle [45] suggests methods for deriving resource weightings in a BOG exercise – similar methods could be applied to a BOCC. More importantly, collecting more than one set of estimates from each country would do much to eliminate, or least ameliorate, the effects of contextual differences.

4.4 The Big MacTM Index

The Law of One Price, which provides the foundation for the doctrine of PPPs has been applied in a very simple way since the 1980s in the formulation of the Big Mac Index. In 1986 *The Economist* magazine first published, somewhat light-heartedly, a comparative index based on a single, tightly-specified manufactured commodity, the Big Mac hamburger [36].

The idea is simple: the Big Mac is offered for sale, with virtually identical specifications, in around 120 countries [49] By assuming that the value of this commodity must be equal in all countries, as it is an identical product, it was argued that the cost of a Big Mac in any country could provide a measure of the relative value of various currencies, and so reflected the purchasing power of a unit of currency in each country. For example, if a Big Mac cost, on average, AU$2.50 in Australia, and US$2.00 in the US, then the exchange rate should be AU$1.00 = US$0.80. If the exchange rate was below US$0.80 then the Australian currency was considered to be undervalued, and vice versa. It was further argued that an exchange rate based on the "hamburger standard" would be far less sensitive to the short term fluctuations that characterise open currency markets.

The idea has been expanded in various ways. Gunther [47] suggests a "Braten[1] index", based on a simple meal of meat with vegetables, as a means of assessing the purchasing power of people in Europe in the 18th century. *The Economist* [49] has compared the costs of a Big Mac in a number of countries with the cost of another standard food item, a "tall latte" as sold in over 30 countries by the Starbucks coffee company.

In essence the Big Mac approach assumes that a single commodity is as representative of domestic consumption as the extensive basket of goods and services used in sophisticated PPP exercises. Pakko and Pollard [48] suggest that the "simple collection of items … does just as well (or just as poorly) at demonstrating the principles and pitfalls of PPP as do more sophisticated measures".

The index has been tested over the years. Ong [32] concludes that the notion of PPP "as a theory of exchange rate determination is probably the most useful and used of all exchange rate theories, despite its many detractors", and (at 29) notes that empirical tests, utilising the Big Mac index to track exchange rate movements have been "surprisingly successful". She concurs with Pakko and Pollard [36], saying that, based on her research, the hamburger index is as reliable as "most other measures of purchasing power parity:"

The index was used the index to compare "real" academic salaries across eight English-speaking countries [32]. The study highlights just how misleading such a comparison can be when based on currency exchange rates. Comparisons of "real" salaries then involved a simple comparison of the number of hamburgers that could be bought in each country. When compared using the exchange rate, a typical Australian salary was only $US38,319; in contrast, when the Big Mac index was applied, the Australian salary had purchasing power equivalent to a salary of $US47,992, making the "real" Australian salary considerably greater than the comparable US salary.

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[1] German for "roast meat"

4.5 Applying "Burgernomics" to Construction

The Big Mac index has been applied in a construction context in only two previous studies [14, 7]. Croce *et al.* [3] were scathing in their attack on the use of the Big Mac by Langston and de Valence, saying (at 21) that

"it should be obvious that countries where food production is not based on wheat, sesame seeds, beef, dairy products, dill pickles and potatoes and where a Big Mac is a luxury item, available only in major cities to urban elites mimicking Western tastes, rather than a fast food staple, is not any sort of a 'standard commodity'".

As discussed above, there is some support for the index in the literature (e.g. [32]). The hamburger actually does represent a variety of inputs provided by a number of industry sectors including agriculture (meat, vegetables, grain), manufacturing (bread, packaging), capital goods (kitchen machinery and buildings), as well as service, finance and direct labour. It also combines a range of tradeable and non-tradeable inputs (rogoff). As it has been estimated that the non-traded component of the cost of a Big Mac is as high as 93% [32], and the proportion of construction inputs traded externally is quite low [13] the index may be particularly well-suited as a deflator of construction costs. While the item may not be fully representative of all countries and regions, it is a commonly available in many places, particularly in large cities, and has been judged (by Ong and others) as a useful tool.

In effect Langston and Best calculated an equivalent costs expressed as "number of hamburgers" by dividing project cost (in local currency) by the local price of a Big Mac. While costs were expressed in US$/m2, costs between countries were actually compared by simply comparing the number of hamburgers that each project "cost". If the Big Mac is accepted as a representative basket of goods, then such comparisons may be the most reliable available method.

5. Conclusions

International comparisons of performance are not easy but a relatively straightforward method has been described. As performance has a number of dimensions the challenge lies in finding a method that is comprehensive enough to be meaningful, but simple enough that it can be applied readily. The Performance Index described here relies mostly on project data that is routinely available within construction organizations, yet it includes, to some degree, the four components of performance, namely, productivity, time, cost and quality. The conversion of costs to a common base is, however, at least as important as the choice of methodology. Different conversion methods can produce significantly different results, and there are no readily available indices that can be applied to construction without the risk of distorted results. The Big Mac Index has been suggested as a viable tool that minimizes some of the problems inherent in such conversions. The best approach is to use as many methods as possible and test the sensitivity of the outcomes. At best, results should be taken as being indicative and not definitive.

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Understanding construction industry competitiveness: the introduction of the Hexagon framework

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Abstract

The link between competitiveness and the sustained prosperity of a nation, industry or firm, is a well established argument and the basis for policy making and strategic changes. However, in order to develop, implement and monitor any initiatives for improving competitiveness, there is a need for a framework through which competitiveness can be measured and understood. This paper reviews the existing frameworks for analysing competitiveness and especially their application to the construction industry. Based on this review of frameworks, a new model to analyse construction industry competitiveness is introduced. Most importantly, the new model distinguishes between the indicators that are used to measure actual competitiveness, i.e. relative efficiency in achieving objectives, and the factors that influence and explain differences in the competitiveness of construction industries.

Keywords: Competitiveness, construction industry, frameworks, measurement

1. Introduction

The research community agrees that despite the increased attention over the past decade and an abundance of literature in the area, competitiveness remains a vague concept and theories and frameworks have yet to prove their relevance in competitiveness practices [1].

In order to develop, implement and monitor any initiatives for improving competitiveness, there is a need for a framework through which competitiveness can be measured and understood. However, both Momaya and Selby [2] and Ofori [3] concluded that no appropriate framework exists for analysing the competitiveness of a construction industry.

The purpose of this paper is to review the existing frameworks for analysing and understanding competitiveness and especially their application to the construction industry. Based on this review, a new framework is introduced, which capitalises on the strengths and weaknesses of the existing frameworks.

2. Characteristics of Competitiveness

Many authors have engaged in an intellectual debate about competitiveness and contributed to a wider understanding of, the subject, so before embarking on the tour of competitiveness frameworks, it is useful to point out some characteristics of the concept.

- *Multi-defined:* There is no general, generic definition of competitiveness and hence the term is subject to misinterpretation and consequent confusion [4, 5, 6, 7, 8].
- *Multi-measured:* There is no single, generic measurement of competitiveness. Instead measurements vary with the definitions [9, 6, 10].
- *Multi-layered:* Competitiveness may be applied at national, industrial and firm levels [1, 7, 11].
- *Dependent:* The meaning of competitiveness depends on the values of the stakeholders of the entity under investigation [2, 6].
- *Relative:* Every measurement of competitiveness needs to be looked at in a relative sense, either against some maximum, ideal level or against its peers [6, 7].
- *Dynamic:* The factors that influence competitiveness change with time and context, e.g. as the national economy moves from a less to a more developed stage [1, 8].
- *Process:* Competitiveness involves assets, processes and performance, where processes turn assets into performance [9, 12].

3. Frameworks for Analysing Competitiveness and Their Application to Construction

This section reviews various competitiveness frameworks and how these have been applied to the construction industry. For further discussion, it is important to note the cause-and-outcome-relationship between the measurement of competitiveness and the understanding and explanation of it. Interestingly, one major criticism of the model used by the World Economic Forum (WEF) in their Global Competitiveness Report, is “that the model does not clearly differentiate between the factors which determine competitiveness of a nation (i.e. causes of competitiveness) and the indicators that are used to measure its competitiveness (i.e. outcomes)” [13, page 121].

The frameworks of competitiveness found in the literature can be divided into three categories, those that:

- Measure competitiveness
- Provide an explanation and understanding of competitiveness
- Integrate the explanation and measurement

3.1 Frameworks for Measuring Competitiveness

This section introduces two frameworks that have been developed with the main objective to produce an ultimate competitiveness score. The score would then enable an assessment of on company's competitiveness in comparison with another.

3.1.1 The Three Dimensions of Competitiveness

Feurer and Chaharbaghi [6] introduce a framework for measuring firm competitiveness. They suggest that a system for measuring competitiveness is dependent on "an organisation's perception of customer and shareholder values, the competitive environment and the drivers that determine competitiveness in that environment" [6, page 54].

The model comprises three dimensions; *Customer values*, *Shareholder values* and *Ability to Act and React*. Each of these dimensions may be quantified using various criteria: e.g. cost and speed; financial key ratios; and financial terms or non-financial terms, e.g. innovativeness or risk management for the three dimensions respectively.

Together, these three dimensions build up a 'room' in which the organisation may map itself in relation to its competitors. The final position in this room "reflects the trade-off between satisfying customer and shareholder values and maintaining financial strength" [6, page 58]. This framework has not appeared in any assessments, or been applied to any industry or firm case.

3.1.2 The Total Value Competitiveness (TVC)

This is a computer-aided decision support system, produced to enable a contractor to assess its own competitiveness, or for a client to assess the contractor's competitiveness. Although it was specifically designed to suit the Chinese construction industry, the methodology may be of use in other countries.

Based on criteria identified by Li and Shen [14], Shen et al. [15], organised their TVC-framework in a three-level hierarchical structure. As illustrated in figure 1, the top-level parameters are; Social influence (CM-A), Technical ability (CM-B), Financing ability and Accounting status (CM-C), Marketing ability (CM-D), Management skills (CM-E) and Organisation structure and Operation (CM-F). Each of these parameters in turn has sub-categories and sub-sub-categories, in all there are 98 criteria, to enable assessments at different levels of the organisation. For each of the 98 criteria, there is a benchmark book that provides a benchmark score from 0 to 100. Furthermore, in order to

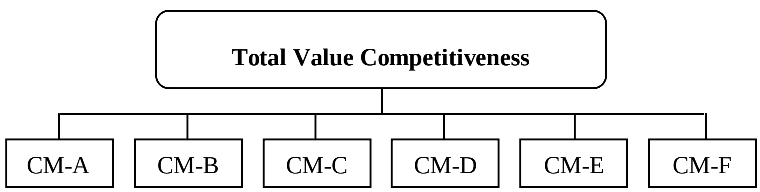

Figure 1: The top-level of the TVC-framework.

acknowledge the varying importance of the various criteria, Shen et al. [15] provide a weighted matrix for each of the different levels of the framework.

3.2 Frameworks for Understanding Competitiveness

This category of frameworks represents attempts to understand and provide an explanation to why some nations, industries or firms meet their objectives better, i.e. more efficiently than their competitors.

3.2.1 The Diamond Framework

By far the most established, applied and debated framework on competitiveness is the 'Diamond Framework', introduced by Porter [4]. He investigated why firms based in a particular nation are able to create and sustain competitive advantage against the world's best competitors in a particular field. Porter concluded on a wide range of factors that influence, determine and explain this international success and categorised these factors under four determinants, which in turn were famously arranged in the shape of a diamond. See figure 2 below.

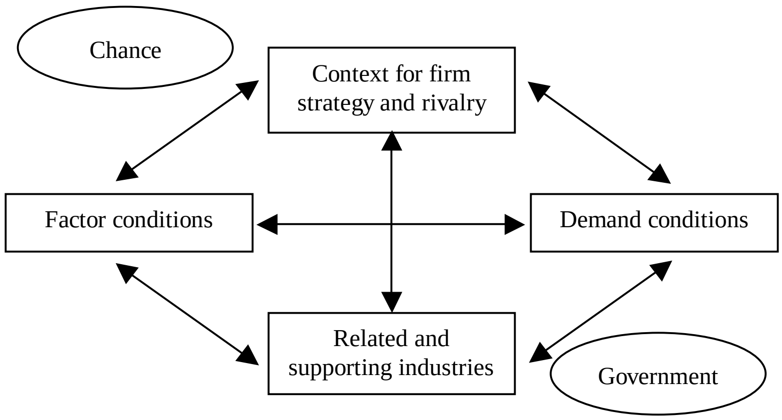

Figure 2: Porter's Diamond framework.

The first determinant, *Factor conditions*, covers factors related to human, physical and knowledge resources. The *Demand conditions* describes the size, structure and sophistication of the home market demand for the products and services of a particular industry. *Related and supporting industries* reflects the presence or absence of internationally competitive related and supporting industries of a particular industry in a nation. The fourth and final determinant, *Firm strategy, structure and rivalry*, includes the strategies and structures of firms as well as the nature of domestic rivalry. For a more comprehensive description of the framework, see [4] and for its credits, criticism and debate, see for example [8] and [16].

Ofori [17] used the Diamond framework to formulate a long-term strategy for Singapore's construction industry, and in Ofori and Betts [18] found it to be a framework suitable for strategic planning in construction. Oz [19] applied the Diamond framework to the Turkish construction industry in order to find the sources of its competitive advantage.

3.2.2 The Double Diamond Framework

As a result of the debate on whether Porter had dealt with multinational activity properly or not, Rugman and D'Cruz [20] introduced the so-called *Double Diamond*, and applied it to Canada [20], Mexico [21] and New Zealand [22]. As a next step Moon, Rugman and Verbeke [23] generalised the *Double Diamond*, see figure 3 below, which, they suggest, will suit all countries and appropriately incorporate multinational activity [8]. The *Generalised Double Diamond* was later applied and tested on Korea and Singapore [24].

In figure 3, the inner-most diamond is identical to Porter's original diamond. The outer-most diamond is also identical in terms of the four determinants, but represents the global context. The dotted diamond is the result of the national diamond as well as international or multinational activities [8].

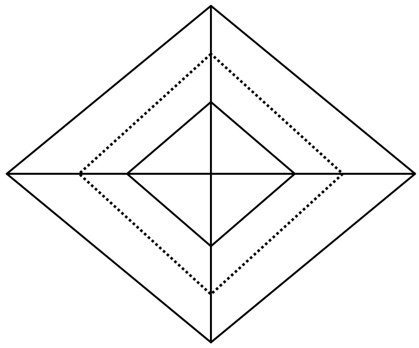

Figure 3: The Generalised Double Diamond framework.

The extensions of Porter's diamond framework have not received very much attention, but they serve as a good starting point for analysis of the interaction between a nation's home base and the global context in which industries operate.

Mutti [25] adapted the *Double Diamond* for assessing the competitiveness of Brazilian contractors in the international market.

3.2.3 The Nine-factor Framework

A second extension of Porter's diamond is presented by Cho [26]. He suggests a regrouping of factors into two main categories: *Physical factors* and *Human factors*. The first category includes; endowed resources, the business environment, related and supporting industries and domestic demand. The four human factors are: workers, politicians and bureaucrats, entrepreneurs, and, finally, professional managers and engineers. Cho's main argument is then that the human factors manage and utilise the four physical factors to drive the national economy from one stage of international competitiveness to the next [8]. This framework does not appear to have received any further attention.

3.2.4 The Competitiveness Triangle

A fourth and final framework for understanding and explaining competitiveness is the Competitiveness Triangle, proposed by Lall [7]. It is similar to Porter's Diamond, but whereas Porter [4] investigated what factors build up national productivity, Lall focuses her analysis on "the markets within which enterprise learning takes place and the failures that each market is liable to suffer" [7, page 20-21]. Lall "puts government policy in the centre of the action", while Porter places the role of government as an exogenous factor [7, page 21].

The Competitiveness Triangle contains three inter-connected determinants. *Incentive markets*, includes a nation's macroeconomic management and trade policies and characteristics of the industry and home demand. *Factor markets* focuses on skills, especially technical skills, and finance for, and information on, technology. *Institutional markets* refers to bodies that support technological activities and development, e.g. institutions for R&D and training and development.

The Competitiveness Triangle has not been applied in any practical case study or received any further attention in the academic literature.

3.3 Frameworks that integrate measurement and understanding

The final category of frameworks are those that integrate the measurement and understanding of competitiveness.

3.3.1 The APP-framework

Buckley et al. [9] noted that definitions and measures of competitiveness vary, and could distinguish three different views of competitiveness - the ability to perform well, the endowment of assets, and the management process. They concluded that all three perspectives must be included in order to unearth a satisfactory view of a nation, industry or firm's sustainable competitiveness.

This school of thought was later adapted by the WEF and the International Institute for Management Development (IMD) in the 1993 World Competitiveness Report under the name of the world competitiveness formula; Assets (potential) x Processes=Performance [27].

The terms Assets, Process and Performance were adopted by Momaya and Selby [1, 2, 28] to become the cornerstones of the APP-framework, see figure 4 below.

Figure 4: The headline factors of the APP- framework.

The first category, *Assets*, represents elements that traditionally have been considered as key sources of competitiveness, but which are "dormant factors unless they are transformed by competitive processes” [28, page 41]. Momaya focuses strongly on the competitive processes, as he views these to be the key to sustained competitiveness [1, 28].

The APP-framework has been used by Momaya and Selby [2] in their study of the international competitiveness of the Canadian construction industry in comparison with Japan and the USA. To quantify competitiveness, they used 95 non-weighted criteria, which were collected both through surveys and published statistics.

3.4 Summary of review of competitiveness frameworks

Table 1 below summarises the main points of interest from the discussion above.

Table 1: Summary of frameworks for competitiveness analysis.

Framework	Author, year	Level	Focus	Applied to construction
The Three Dimensions	Feurer and Chaharbaghi, 1994	Firm	Measurement	No
Total Value Competitiveness	Shen and Lu, 2002	Firm	Measurement	Yes
The Diamond	Porter, 1990	Nation, industry	Understanding	Yes
The Double Diamond	Moon, Rugman and Verbeke, 1995	Nation, industry	Understanding	Yes
The Nine-Factor Model	Cho, 1998	Nation, industry	Understanding	No
The Competitiveness Triangle	Lall, 2001	Firm	Understanding	No
Assets-Processes-Performance (APP)	Buckley et al., 1988; Momaya and Selby, 1998	Nation, Industry and Firm	Integration of understanding and measurement	Yes

4. The development of a new framework for analysing construction industry competitiveness

According to Lall [7], a complete competitiveness analysis must: (1) define what competitiveness means and how it is to be measured and, (2) identify the most important factors influencing it, the interactions between these factors and how they affect the competitiveness of the subject of investigation. This fits in with the earlier observation, and also with the underlying thinking of the APP-framework, i.e. the appropriateness of distinguishing between the causes and the outcome of competitiveness.

Hence, a framework for analysing construction industry competitiveness should consist of two separate but yet interconnected parts – one for the measurement and one the understanding. The latter is used to understand and provide explanations to the scores, differences and trends of the measurements of competitiveness.

4.1 Defining and measuring construction industry competitiveness

Any definition of competitiveness should consider the perspectives of the stakeholders of the subject under investigation [6]. Furthermore, the aspects of the definition, i.e. the stakeholders' perspectives, should be covered in the quantification of competitiveness [2]. In their definition of competitiveness, Momaya and Selby [2], include the satisfaction of shareholders', employees' and clients' needs.

The authors propose a fourth stakeholder that a competitive construction industry needs to satisfy, - the overall society, i.e. the society in which the construction industry operates. Society at large, or more exactly a nation's tax payers, is indirectly the largest client of the construction industry. Moreover, the industry generally makes up a large percentage of a nation's GDP, approximately 10% in the case of the UK [29], and is one of a nation's major job-creators. Consequently, inefficiencies in the industry have a great negative impact on the economic well-being of the country. Many construction processes, including city planning, have a significant impact on the physical environment and their deliverables have a long-term impact on the public's social well-being. The Confederation of Finnish Construction Industries states in its mission that the construction industry should supply 'practical, healthy, secure and cost-efficient buildings', and 'act in a socially responsible way to contribute to national wealth, whilst upholding its responsibility for the environment' [30].

Table 2 below, presents a suggestion of the broad indicators that may be used to provide measurement of construction industry competitiveness.

Table 2: Examples of competitiveness indicators for different stakeholders of the construction industry.

Stakeholder	Shareholders	Employees	Clients	Society
Competitiveness indicators	Profitability	Health and safety	Time and cost predictability	Environmental consciousness
	Growth	Wage level	Quality of product	Business ethics
	Productivity	Work hours	Life cost	Corporate social responsibility
	Equity-asset ratio	Power of unions	Service	Inclusion

4.2 Understanding construction industry competitiveness

The next step of the analysis is to identify and organise the factors that explain construction industry competitiveness. As a starting point, it is important to consider the conclusions drawn by Ofori [3]. He suggests that "In developing a model for analysing international construction, it would be relevant to consider the four determinants in Porter's diamond, as well as culture and institutional arrangements and government's influence. Chance would be an exogenous variable. Each of these seven factors should have an international dimension. Thus, each company's or industry's competitiveness would be depicted by a series of linked (national) diamonds" [3, page 389]. It is interesting to note that the construction industry was not the focus of any of the frameworks explaining competitiveness as discussed above, and thus it is likely that some aspects characteristic to construction have not been taken into account.

Following Ofori's suggestions, the framework for understanding construction industry competitiveness originates from Porter's Diamond framework. However, a number of alterations are proposed in the next section.

4.2.1 Porter's Factor conditions

The construction industry is labour intensive. Labour forms a large percentage of the cost of a project and labour productivity is in many cases used as the only measurement of competitiveness. The work environment, including health and safety, and investment in training are considered as important areas for construction. However, in Porter's Diamond, factors related to human resources/labour is included in factor conditions. In order to highlight their importance for construction industry competitiveness, they are put in a determinant of their own.

Thus, Porter's *Factor conditions* are split into *Human resources* plus *Factor conditions*. A similar alteration was suggested in the formulation of the Nine-factor model [26].

Human resources, covers aspects like: availability, skills and commitment of labour; work environment (physical and psychological); work conditions (compensation system, work hours, labour market regulations) and workforce characteristics. *Factor conditions* includes: availability, cost and sophistication of material, equipment and ICT; financial market conditions (ease of access to loans, rate and stability of interest and exchange rates) and country characteristics (climate, geographical location, political stability, and infrastructure).

4.2.2 Porter's Demand conditions

Porter devoted *Demand conditions* as a determinant in itself. As these conditions play an important role in the performance of a construction industry they are kept unchanged. This determinant includes for example: size and structure of home market and sophistication of clients' needs and procurement practises.

4.2.3 Porter's Related and Supporting Industries

The scope of the framework that is to be developed is a nation's construction industry, including material suppliers, designers, engineering consultants and contractors. In Porter's Diamond these would instead have been treated as individual industries, i.e. designers would have been seen as a related and supporting industry to contractors. This shift of focus implies that the area of related and supporting industries will not be given the same attention as it was from Porter. Thus, the role of Porter's *Related and supporting industries* is left out in this framework.

4.2.4 Porter's Context for firm strategy and rivalry

The context for competition and collaboration within an industry is of major importance to the performance of that industry [4]. However, since the agenda within the industry as a whole is different from that of an individual firm, it is appropriate to separate the macro and micro levels and devote each of the levels to one determinant in the adapted framework. At the industry level, the focus is on competition and collaboration in the industry and its image. At the firm level, management practices, project management skills and in-house R&D are major areas of interest. Thus, Porter's *Context for firm strategy and rivalry* is split into *Firm strategies, management and organisation* and *Industry characteristics*.

The former determinant relates to firm's specific practices like: goals and strategies; supply, financial and marketing practises; organisational structure, communication and decision-making mechanisms; R&D activity; and production processes. *Industry characteristics* is devoted to: presence and power of trade, client and employee associations; intensity, fairness and sophistication of competition; and integration and collaboration of industry stakeholders.

4.2.5 Government

The role of government was considered by Porter as an exogenous factor. However, government activity is of major importance to the construction industry, not only in shaping the business environment and setting market regulations, but, for construction, also as a major client or market intervener.

In this adapted framework, *Government* is shifted from an exogenous parameter to a determinant of its own. This is supported by Lall [7] who gives government a central position in her *Competitiveness Triangle* and also by the criticism that Porter's Diamond underestimated the influence of government [31, 32]. This determinant covers issues like: the tax system and bureaucracy, policies, incentives and regulations on, for example, environmental, ethical, health and safety issues, and the presence and power of a single construction authority.

4.2.6 The exogenous dimensions

To complete his Diamond, Porter adds the two exogenous dimensions of government and chance. His positioning of these dimensions is due to their influence on the other four determinants, but at the same time they are outside the immediate control of firms [4]. In the suggested framework, adapted for the construction industry, the role of government has been shifted to become a determinant of its own. The impact of chance, however, can neither be neglected nor predicted or measured. For a nation's construction industry, chance may refer to events either in the domestic or international market. For example, in the home market the risk of political instability or geographical proximity to markets that are becoming more competitive [19].

Another area of criticism of the diamond framework is that the framework should incorporate the impact of culture [3, 33]. In the adapted version of the framework, this suggestion is acknowledged and accordingly the role of national, industry and firm culture becomes an exogenous dimension. This dimension covers aspects such as: the attitudes of managers and the workforce towards innovation, business ethics, and the nature of employer-employee-relationships.

Thus, in this adapted framework, there are two exogenous dimensions – the role of chance and the impact of culture – that influence all of the six determinants of the framework, but are out of the industry stakeholders' immediate control.

4.2.7 The domestic construction competitiveness hexagon

The Domestic Construction Competitiveness Hexagon is a framework to organise the factors that influence the competitiveness of nation's construction industry, i.e. its ability to satisfy its stakeholders; shareholders, employees, clients and overall society. In summary, the suggested framework consists of six determinants, which are organised in the shape of a hexagon, and two exogenous dimensions, see figure 5. The determinants are, like the ones in Porter's Diamond, mutually dependent in the sense that the state of one affects the others' and thereby form a dynamic system [4]. For example, government policies will affect the sophistication of the clients' needs, which will in turn have an effect on firms' strategy.

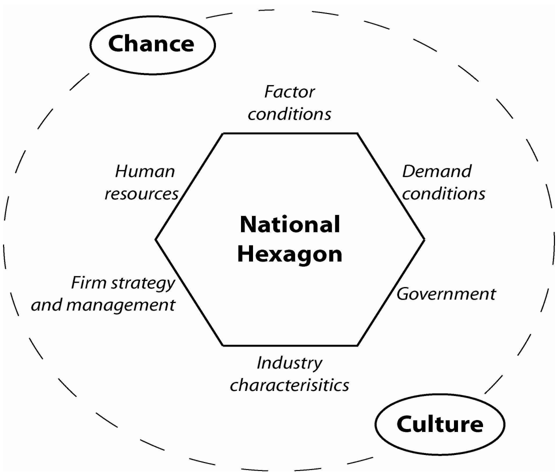

Figure 5: The Domestic Construction Industry Competitiveness Hexagon.

4.2.8 International activity: the complete hexagon framework

As discussed above, the determinants of the domestic hexagon framework are inter-dependent and also affected by chance and culture. However, in times of increased globalization of supply and lowered barriers to entry markets previously dominated by domestic firms, there is an obvious international dimension that poses both threats and opportunities to a nation's construction industry.

The international dimension captures the international aspects regarding: supply of material and equipment, mobility of workers, demand conditions, and competition.

The incorporation of international activity is also the area where the Diamond framework has received the most criticism [20, 21, and 22]. As discussed earlier, the result of that debate was the *Generalised Double Diamond* framework [23]. In order to respond to the need of an international dimension, the domestic hexagon framework adapts this 'double-design' to form the complete *Construction Industry Competitiveness Hexagon*, see figure 6.

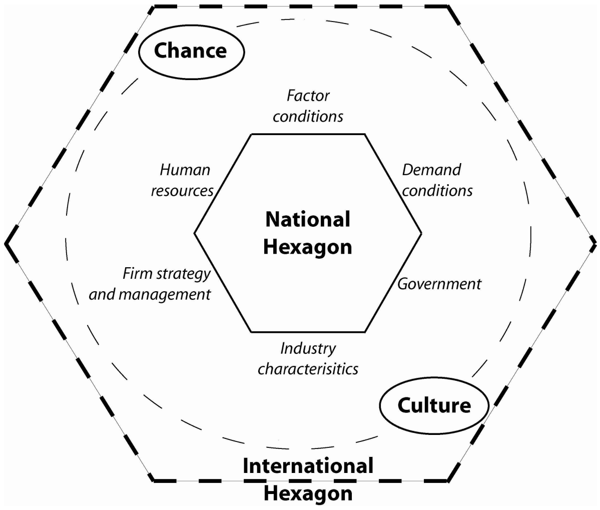

Figure 6: The Construction Industry Competitiveness Hexagon.

5. Conclusions

Competitiveness is vague concept that may be defined and measured in a number of ways. The measurement is dependent on the definition employed. Competitiveness may be applied at national, industry or firm level and depends on stakeholder values. It should be seen in a relative sense and from a long-term perspective.

There are three kinds of frameworks for competitiveness analysis; those that measure competitiveness, those that attempt to explain and understand competitiveness, and the frameworks that integrate the explanation and measurement. The paper reviews a total of seven frameworks, of which four have been applied to the construction industry.

Based on the review, this paper introduces a new way of analysing construction industry competitiveness. It does so by explicitly distinguishing between the measurement of competitiveness and the analysis of the factors that influence competitiveness. Furthermore, besides shareholders, employees and clients, overall society is brought in as a fourth stakeholder of the construction industry. In order to conceptualise the factors that influence the competitiveness of the construction industry, this paper extends Porter's Diamond by acknowledging the suggestions put forward by Ofori [3]. The resulting framework – *The Construction Industry Competitiveness Hexagon* (CICH) – consists of six determinants, each attached to an international dimension. The determinants are mutually inter-dependent and are further affected by the two exogenous dimensions of culture and chance. The authors believe that the CICH framework serves as a good starting point for understanding the competitiveness of a construction industry, but they realise that further research is needed in order to identify the most important factors that influence construction industry competitiveness.

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Construction Innovation Systems - a Sector Approach

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Abstract

Recent studies depict the general need to increase and improve innovation in the construction industry. Innovation processes are traditionally described and analysed either on a macro level or a micro level. Production in construction is basically project oriented, as opposed to manufacturing industries for which most of these theories are developed. It is not fully sufficient to study innovation from a micro or a macro level due to the effects of the project orientation and the large number of actors in the construction industry. The objective of this paper is to present a model of the construction innovation systems from a sector systems approach. The study rests upon findings in the area of innovation systems in general and construction innovation systems in particular on one hand and construction sector systems analysis on the other. This paper presents arguments for the development of activity based innovation systems at a construction sector level.

Keywords: Construction Innovation, Innovation, Innovation Systems, Construction Sector, Sector Analysis

1. Introduction

The construction industry, as well as any other type of industry, develops continuously. The momentum and impact of construction development is influenced by a complex system of different elements [1]. Knowledge about the characteristics of the industry, its driving forces and external influences, are of basic importance when to understand the development of construction [2], i.e. when to understand the construction innovation systems [3]. Recent studies depict the general need to increase and improve innovation in the construction industry and the need for better understanding of the innovation processes of construction as to gain construction innovation [4][5][6].

Innovation processes are traditionally described and analysed either on a macro (national) level or a micro (company) level [7]. Existing theories of National Systems of Innovation are used on the macro level [8] while Firm Centred Knowledge Networks or Complex Product Systems are examples of innovation theories applied on the micro level [3].

Production in construction is basically project oriented, as opposed to manufacturing industries for which most of these theories are developed, and involves a large number of specialised actors from different branches of industries. Further, construction is closely connected to the national social structure and consequently, is highly influenced by local, governmental and other institutional actors [9]. Due to the effects of the project orientation together with the large number of actors in the construction industry is that in many cases it is not sufficient to study innovation from a micro level as a single company is depending on the actions of their collaborators. The effects on a macro level are that the relations between the actors of the industry are not static but varies from project to project, thus the national systems of innovation has more of an occasional character in construction than national systems of innovation in traditional manufacturing industries. Thus, a comprehensive approach is needed to understand the wide and complex characteristics of construction and its innovation systems.

The objective of this paper is to present a model of the construction innovation systems from a sector systems approach, i.e. a comprehensive approach to construction that includes the actors involved in the whole lifecycle of construction as well as institutional actors at the international, national, regional and local level. The purpose of the study is to induce a discussion about construction innovation systems at a sector level as a complement to identified shortcomings of established approaches of national innovation systems and micro level systems. The study rests upon findings in the area of innovation systems in general and construction innovation systems in particular on one hand and construction sector systems analysis on the other. The study constitutes a theoretical approach to construction innovation systems based on literature.

2. Characteristics of Construction

The specific characteristics of construction is frequently described in literature, e.g. the physical nature of the product of construction and the structure of industry [10], the production of single/unique structures and the diversity of clients [11], the importance of maintenance works [12], itinerant production and the derived nature of demand [13], the long term use of structures [14], diversified client categories such as households, firms and government [15]. The construction process is inherently complex and to a large extent fragmented with many actors working together in ever changing project organisations [16].

Describing innovation systems of construction requires a thorough understanding of the characteristics of construction. The construction sector covers a wide scope of activities, it involves a great variety of actors and it is externally influenced by its market and institutional environment. Construction includes such diverse economic activities as new production and repair/maintenance, itinerant production and stationary manufacture, the production of buildings and constructions, and it involves a large number of actors representing different professions and types, e.g. companies, public utilities and private persons.

3. Innovation

The definition of innovation is some what unclear, many different exist. OECD defines it as "A technological product innovation is the implementation/commercialisation of a product with improved characteristics such as to deliver objectively new or improved services to the customer. A technological process innovation is the implementation/adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these"[17]paragraph 24. The similarity between most of the definitions is that they include creating a new product or process, and putting it to use [18]. It does not however state that it has to be new for everyone since it is enough to be new for those adopting it. Innovation is not the same as invention; invention is the new idea that may lead to an innovation through the innovation process, see fig. 1.

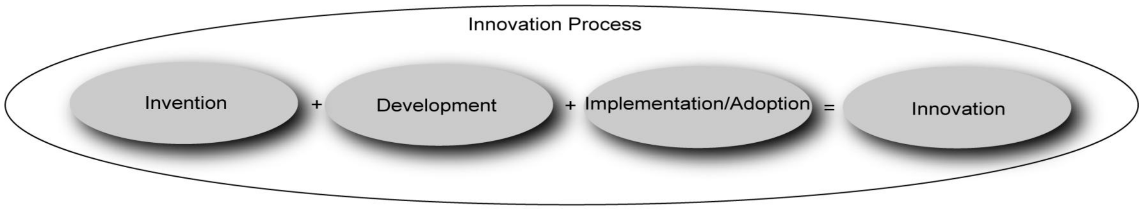

Figure 1. The relation between invention and innovation in the innovation process. (adapted from [19]).

3.1.1 Innovation from a macro-level perspective

In the last decades there has been a great interest in using National Systems of Innovation (NSI) to explain differences in the ability of countries to foster and develop innovative capabilities. Early on, the concept of NSI was defined as the set of institutional actors that plays a major role in influencing innovative performance nationally [20]. According to Edquist [8] p 182 "systems of innovation = the determinants of innovation processes = all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovations. With a national perspective SI consists of two main components, organisations are actors and institutions are the rules of the game; laws, common habits, norms etc [8].

On the macro level there has been some resent research on national systems of innovation or related areas for the construction industry, e.g. [21], [3], [2]. Much of the work has not been on national systems of innovation as such, but on national construction business systems [2]. In these studies the relationships between institutional factors, companies, education etc. are studied. National patterns and characteristics are used to understand and explain the business capabilities. Regulation is one aspect of national innovation systems that has been studied [22]. In one international study on national systems of innovation the focus was on public policies, and their link to political systems, and their influence on the national systems of innovation [3]. In Sweden a national innovation system has been described [21] identifying six important groups of actors;

clients, service providers, suppliers, universities and colleges, research institutions, and research financers.

Together these different studies do cover a large part of the different parameters within national systems of innovation. One part that is not covered in any particular way is the effects of the project-based situation on national systems of innovation. When using the national systems of innovation on a manufacturing sector the relations between the actors are rather fixed making the systems static. The project focus together with that some actors can play different roles in different projects alters the construction sector systems continuously. The systems are unstable and it is inappropriate to use for general analyses.

3.1.2 Innovation from a micro-level perspective

Brown and Eisenhart [7] have identified three streams in literature regarding the organization-oriented tradition; rational plan, communication web and disciplined problem solving. The rational plan is that a well planned and implemented product that has the right support will be a success. The communication web is that the better members are connected with each other and with key outsiders the better the development process. The disciplined problem solving is a balancing act between autonomous problem solving project teams and the discipline of a heavy weight leader.

Regardless of how the innovation approach is described there are many factors which influence a company's ability to innovate, important examples are competence and knowledge [23], communication [24], learning [23][25], relationship and co-operation with other actors [23][26], and risk capital and reward [23][27].

The theories of innovation steams to a large extent from manufacturing and most often assume that work in support of innovation takes place within the same company. One theory that contrasts with traditional innovation theories and models is CoPS (Complex Product Systems). These are defined as "High cost, technology-intensive, customised, capital goods, systems, networks, control units, software packages, constructs and services" [28] p.793.

There has been some research done on the innovation in the construction firm ([16]). The research is very dispersed, issues concerning, specific parts of the construction sector [29][30], specific actors or groups of actors [31][32] small businesses [33][34], some work on construction material and equipment providers [20], learning [35], teaching [36]. This research covers many of the different areas thought to be important in traditional innovation theory. The aspect that is missing is the contextualisation needed to fit it into the project-based construction process.

Many of the different authors have stated that collaboration between different actors is important especially as the construction process is so project focused as it is. Construction innovation on the part of the primary actors – designers and contractors – outside projects appears to be rare [37]. How to understand this innovation collaboration and how to develop it long-term are rather unstudied areas. As a result ideas that occur on a daily basis on the construction site and in research and development environments normally, literally, have no place to go [38].

As much innovation takes place within the daily projects, the ability to implement innovations is often not depending on one company, thus a micro-level focus will not be fully sufficient to explain implementation success or failure in construction.

4. Construction Sector Systems Analyses

A traditional way to approach construction is by the construction process model that describes the main phases of a general construction project, i.e. development, design, construction and operation. The phases of the process model of construction are independent of project type and scale, procurement systems, numbers of actors involved or where the project is located. For example, Bonke [39] presented a construction process model with the aim to provide a general model applicable in an international context and of course other outlines of the process model are available in literature (e.g. [40][41]). A general construction process model, standardised even on an international level, provides a basis for analysis of construction, such as information and knowledge management, business relations, risk mitigation, productivity, benchmarking analyses, etc. An organisation can position itself relative to other actors and apply the analysis specifically focussed on topical targets or core areas based on the general model [41]. However, the construction process model basically describes the creation process of a construction product and as such it emphasizes the production phase. Thus, the construction process model is too narrow to describe and understand the full scope of actors and activities in the construction sector [42], and consequently, a more comprehensive approach is needed when to analyse construction innovation systems.

In this paper, a construction sector systems analysis, established by [41], will provide a model describing construction innovation systems applied at a sector level. The construction sector systems analysis, referred to as the sector model, aligns with the structure of a systems analysis, with specific emphasis on a comprehensive aggregation level and consideration of the influences of the institutional environment. Thus, the sector model describes the construction sector as an open system, composed of interacting components that carry out economic activities ranging from manufacture, production, to asset management.

The construction sector systems include not only on-site production activities but also the operation and maintenance of existing structures, the manufacture of building materials and equipment, real estate management etc. The system environment consists of external elements that in one way or another influence the system. The construction sector systems model specifically considers the institutional environment, as an important aspect that influences the sector. In the case of construction, the role of institutional actors is twofold, as they constitute part of the system's environment in their role as policy makers, but also as components of the systems, principally as clients or as public companies competing at the market. Another external influence on the construction sector systems comes from the state of the market, the interest rate level, etc. This external influence is referred to as the market environment, or simply the market.

The economic activities of the sector model are divided into three main activities of construction, namely manufacture and distribution, project-related activities and, asset management, i.e. real estate and property management etc. In the sector model, these three activities are described along the vertical axis, dividing the model into three sections, see figure 2. The type of construction works for each of the main activities are described along the horizontal axis and are divided into new construction, management of service and demolition. Consequently, the overall horizontal direction describes the life cycle of the building or construction while the more detailed, horizontal level represents the different phases of the construction process. The vertical direction correspondingly indicates the value chain of construction, from the initial manufacture and distribution to the onsite production in which the new construction is prepared and on to the maintenance of the completed structure.

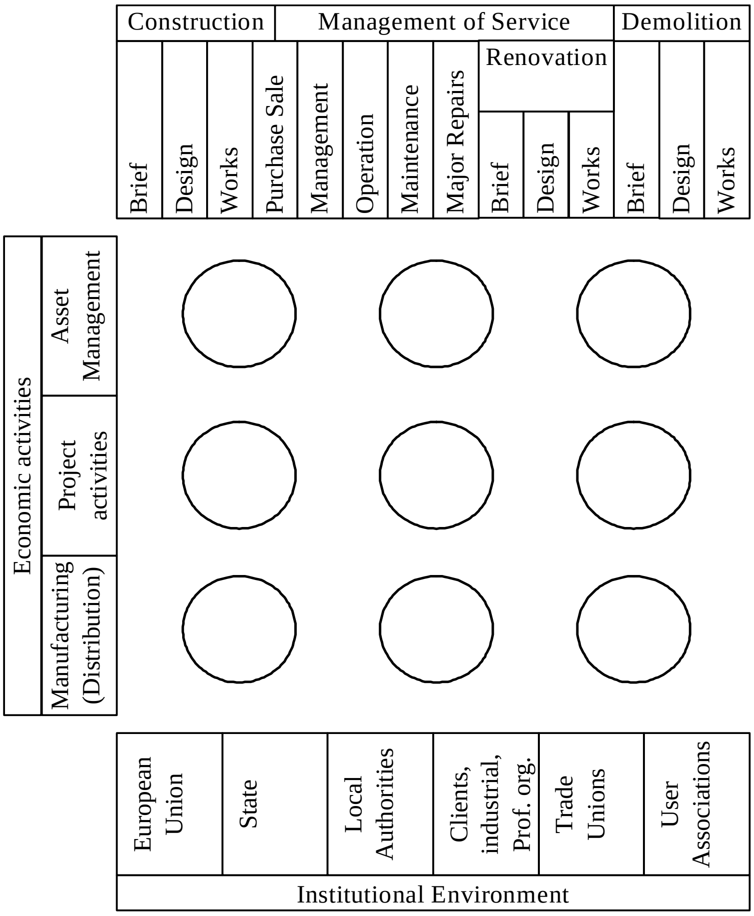

Figure 2. The construction sector systems model [41]

The various actors constitute the components of the systems, those actors are grouped together in boxes according to the construction activities they perform, and the phases of the life cycle they support. One category of actor, e.g. contractor or architect, can be represented in more than one construction activity.

As the sector systems of construction are described as open systems, they are influenced by the external environment, i.e. the surrounding market and the institutional environment, which is specifically emphasized. Thus, in the sector model, the institutional environment is represented by different institutional actors, which are graded from left to right, with the most comprehensive institutional actors to the left, starting with the European Union, down to trade unions and tenants' associations.

5. Activity Based Innovation Systems

The principal suggestion in this study is to use the sector systems model presented above as a framework for an innovation system at a construction sector level. This implies an innovation system that is established at a construction sector level in which the components of the system are constituted by the economic activities of the system. The argument for such a system rests upon the earlier deficiencies described for macro- and micro innovation systems in the case of construction.

The activity based construction innovation systems includes the temporary and itinerant project related activities as well as long-term manufacturing. National innovation systems are traditionally designed for manufacturing industries and, according the discussion earlier, has difficulties in describing project oriented industries as is the case for construction.

The activity based construction innovation systems captures the whole lifecycle of construction, including the early stages of manufacturing through to the final demolition, and thus, does not solely concentrate on the short-term production phase. Consequently, the effect of innovations in one phase of the lifecycle can be analysed in a long term perspective. This is of course of specific interest in construction due to the long-term nature of construction products. Neither the macro- nor micro-level innovation systems handle the specific requirements of construction regarding the time aspect.

The national innovation systems include the aspects of institutional actors, which has great influence on construction. Accordingly, institutional actors are identified as an important part of the sector system model.

The basic argument for the activity based innovation system is, however, the way it handles the great variety of actors that are involved in construction. A specific characteristic of actors involved in construction is that their roles change from project to project. For example, a subcontractor in a large project can be a main contractor in a smaller project. A manufacturer generally produces building material but can also transport and assembly its components on site.

A contractor either produces and delivers a building to the client or acts as both client and producer when using a direct labour approach. Thus, the fundamental principal of the sector systems model is that its components are not constituted by its actors, but by its economic activities. These activities ought to be the same regardless of procurement system, size or type of a building project, location etc., which makes the activity based innovation systems stable.

6. Conclusions

This paper presents arguments for the development of activity based innovation systems at a construction sector level. The argument is solely based on literature about established innovation systems as well as construction sector analysis and consequently, the suggested innovation system is not tested. The purpose of the paper is namely to contribute to and open up for a critical discussion about activity based innovation systems at a sector approach.

As the innovation systems are based on activities, it is obvious that the definition of activities, i.e. the detailed level at which the activities are described, are crucial to the applicability of the system. However, the outline of the sector systems model remains intact and thus, the breakdown of activities into smaller units can adjust the required detail level of a specific analysis while the outline of the sector systems model remains the same.

Another difficulty about the activity based innovation systems ought to be the identification and analysis of the relations between the components, i.e. the activities. This problem is, however, not unique to the activity based innovation systems, but occurs in any systems analysis.

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Impact of procurement method on costs of procurement

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Abstract

Collaborative working methods offer the hope of reduced waste, lower tendering costs and improved outputs. The costs of tendering may be influenced by the introduction of different working methods. Transaction cost economics appears to offer an analytical framework for studying the costs of tendering, but it is more to do with providing explanations at the institutional/industry level, not at the level of individual projects. Surveys and interviews were carried out with small samples in UK. The data show that that while tendering costs are not necessarily higher in collaborative working arrangements, there is no correlation between costs of tendering and the way the work is organized. Practitioners perceive that the benefits of working in collaborative procurement routes far outweigh the costs. Tendering practices can be improved to avoid waste, and the suggested improvements include restricting selective tendering lists to 2-3 bidders, letting bidders know who they are competing with, reimbursing tendering costs for aborted projects and ensuring that timely and comprehensive information is provided to bidders.

Keywords: procurement, cost of tendering, bidding cost, transaction cost economics.

1. Introduction

The increasing use of collaborative working methods in the UK is displacing more traditional competitive methods for selecting contractors and consultants. This move is accompanied by reduced reliance on the law when things go wrong. Proponents of collaborative working claim that the elimination of competitive tendering will reduce the costs of striking deals, whereas those who favour more traditional procurement claim that the costs of negotiation are much higher than the costs of competition. This paper reports the final results of research that has previously been reported to CIB conferences as work in progress [1, 2, 3].

1.1 Theoretical Work on Costs of Transactions and Costs of Tendering

Transaction cost economics (TCE) offers insights into the analysis of the costs of organizing the procurement of construction work in different ways. Coase [4]**{** XE "Coase, R H" \f “a” **}** suggested that transaction costs**{** XE "transaction cost economics" **}** were the key influence on a firm’s decision about whether to produce inputs in-house or buy in goods and services (the make-or-buy decision). Finding the right contractor and agreeing a price is complex and requires binding contractual arrangements. Contractors, particularly in the UK, generally use sub-contractors rather than employing labour directly. The costs of purchasing these inputs, and ensuring that they conform to specification, are high. All these are costs of procurement; the subject of this study.

1.1.1 Transaction Cost Economics

Williamson [5] stressed the importance of comparative analyses of the costs of different modes of organizing productive activities. But reality is fuzzier than a simple choice between market and hierarchy in that markets are often characterized by networks of participants, creating regular relationships in what is sometimes referred to as a *quasi-firm* [6]**{** XE "quasi-firm" **}**. Such networks are increasingly prevalent in the construction industry, with the growing popularity of partnering**{** XE "partnering" **}**, etc**{** XE "strategic alliancing" **}**. The ideas of Coase and Williamson have been taken up by many who study business processes [7, 8]. These ideas seem to hold out a lot of promise for analysing and describing the situation in the construction sector.

1.1.2 Transaction Costs in the Construction Industry

Several authors have sought to explain contracting in the construction industry, by using TCE**{** XE "transaction cost economics" **}** [9, 10, 11, 12, 13]. Indeed, there is some empirical research to support the transaction cost concepts [14, 15]. Dietrich**{** XE "Dietrich, M" \f “a” **}** [16] is critical of using traditional transaction costs theory to explain the construction sector, because it ignores the inherently dynamic nature of contracting and organization problems. Dietrich re-casts the costs of transactions in terms of the management costs associated with forming and enforcing contracts and presents this as a means for comparison with production costs. Such an approach enables both transaction and organization costs to be understood as the costs of management, whether in-house or not. These are the costs that we seek to measure when comparing different ways of organizing construction work. The literature reveals little empirical work that tests the reliability of these theories in industry generally, or in the construction sector in particular.

1.1.3 The Failure of Transaction Cost Analysis in Construction

{ XE “transaction cost economics:failure of, in construction" **}**High transaction costs may imply that it would be economical to bring inputs in-house and avoid the costs of arranging sub-contracts. Theoretically, there should be a movement towards the internal labour market and away from subcontracting [17]. But in the UK the trend is the other way, questioning the relevance of TCE in the construction sector.

{ XE "sub-contracting" **}**Hillebrandt**{** XE "Hillebrandt, P M" \f “a” **}** and Cannon**{** XE "Cannon, K" \f “a” **}** [18] list five characteristics of construction which affect the division of work between direct work and that which is sub-contracted:

- The finite construction period of each project.
- The wide geographical spread of location of projects.
- The uneven requirement for specific skills over the life of the project.
- The wide diversity of skills required.
- Fluctuations in the demand for any particular type of work.

These factors far outweigh the theoretical reasons which favour the internal labour market and result in the widespread sub-contracting of the UK industry. Buckley and Enderwick [17] accept that these factors explain the situation on the ground. There may well be similar problems in applying TCE to the tendering situation. The mere fact that sub-contracting seems more expensive than direct labour is not sufficient reason to call for less sub-contracting. The important decision in the construction industry is not whether to outsource, but how best to structure relationships.

Construction projects are geographically dispersed**{** XE "sub-contracting:reasons for" **}**. A large construction firm may be operating anywhere in the UK, perhaps anywhere in the world. Transport costs of materials make it economic to procure them near to site. If a contractor had produced components in-house, costs of transport would generally cancel any cost advantage in production and transaction costs. Moreover the diversity of components and materials used in different projects would make it unlikely that more than say 10-20 % of inputs could be produced in-house [19: Table 10.5].

Similarly with labour requirements: Before the Second World War, and for a few years afterwards, contractors employed their labour force directly. This was easier when contractors were smaller. They would find continuous employment for their best operatives, but a large number, although directly employed, were in fact casual labour**{** XE "labour:casualization of" **}**, taken on for a few weeks while their particular trade was required on a project. This was unavoidable because, apart from wide geographical spread of work, any one trade was needed for only a part of the duration of the contract. The total amount of labour resource required by a contractor is small at the beginning and the end of the contract, with the bulk of the work being done in the middle. Moreover, each individual trade does not form a constant proportion of the whole [20: Table 4]. The labour-only sub-contracting**{** XE "sub-contracting:labour-only" **}** system in use in the UK replaced direct, but largely casual employment.

The geographical dispersion of projects and the variations in the employment of specialist inputs over the duration of the project completely override the arguments of transaction cost theory**{** XE “transaction cost economics:failure of, in construction" **}** for in-house production and employment. There is an overwhelming advantage in the modern construction industry in sub-contracting as opposed to direct employment and of buying in materials and products rather than manufacturing. This then raises the problems of organizing the commercial process in the optimum manner, a subject on which this research project makes a significant contribution.

1.1.4 Categories of Costs of Procurement

Following Williamson**{** XE "Williamson, O E" \f “a” **}** [21], it is useful to distinguish *ex ante* from *ex post* transaction costs**{** XE "transaction costs:*ex ante*" **}{** XE "transaction costs:*ex post*" **}** [22]. *Ex-ante* costs include the costs of tendering, negotiating and writing the contract while *ex-post* costs may be incurred during the execution and policing of the contract or of resolving disputes arising from the contracted work [21]. *Ex-post* costs include direct costs such as the cost of implementing control systems, cost accounting, measuring performance, quality assurance systems and layers of the managerial hierarchy [9]. *Ex-post* costs arising from disputes and litigation may also be high. *Ex ante* costs were tentatively identified as those incurred in (for example) contractor selection.

Lingard et al. [22] observed that some theorists argue for three categories, namely; search and information costs, bargaining and decision costs, policing and enforcement costs. These categories are roughly equivalent to the classification of transaction costs suggested by Gruneberg and Ive [23] as: search costs, product or service specification costs, contract selection and negotiation costs, supplier selection costs, performance monitoring costs and contract enforcement costs. These are more specific than the two argued for by transaction cost economists, and for the purposes of more detailed analysis can be re-stated as: pre-tendering work, tendering work and post-tendering work. However, the third category is too broad in that it includes routine management as well as dispute resolution. It is more useful to separate dispute resolution, especially in the light of contemporary developments in procurement practice specifically designed to avoid disputes in the first place. Thus, the commercial process has been divided into four stages for the purposes of this research; the management costs of which are influenced by each other. These are shown in Table 1.

*Table 1: Stages in the commercial process**{** XE "commercial process:stages in" **}***

Marketing	Developing relationships and selling, including pre-qualification for preferred tender lists, forming alliances, establishing reputations.
Agreeing terms	Pricing and scoping work, estimating, bidding and/or negotiating perhaps with some element of design, and fixing a price (for consultants, defining a fee and terms of engagement); this is the process of striking the deal and at this stage a contractual relationship comes into being; the result is an offer, which may be accepted by the “customer” saying “yes”.
Monitoring of work	Managing the realization of the design, monitoring performance, ensuring the carrying out of contractual obligations during the contract period, the result is the building.
Resolving disputes	Dispute resolution after the contract period, there are two types - agreeing what is owed and recovering what is owed, i.e. bad debts. Claims, enforcement and disputes, the result is the discharge of contractual obligations.

The research project is concerned with an examination of the costs associated with each of these four commercial processes in construction.

As well as the costs incurred in selling goods and services, costs are also incurred at each stage by the buyer of goods and services. Together, these involve substantial resources which are typically dealt with as overheads.

These activities have been part of the construction process from early times [24]. By the middle of the 20th century the UK Government was becoming concerned at inefficiencies and waste in the system, particularly as administered by local authorities, and as a result, a series of reports was produced to try to improve procurement [25]. The earlier reports concentrated on improving the tendering system and more recently the need for more collaboration. The way that collaboration takes place is still developing.

1.2 Empirical Work on Factors Affecting the Costs of Procurement

{ XE "transaction cost economics:empirical work" **}**There have been some attempts to quantify the costs of transactions. Masden *et al.*'s [26] **{** XE "Masden, S E" \f “a” **}{** XE "Meehan, J W" \f “a” **}{** XE "Snyder, E A" \f “a” **}** study relied on a limited number variables and respondents giving an ordinal score to the importance of each factor, related to decisions about in one firm involved with a shipbuilding contract. They identify the difficulty of obtaining data as the key obstacle to testing transaction-cost theory, particularly as every case seems to be specific to a particular situation.

Chang**{** XE "Chang, C Y" \f “a” **}** and Ive**{** XE "Ive, G" \f “a” **}** [26] undertook an institutional analysis of transaction costs in construction, to ascertain the most effective way of organizing market relationships. They consciously avoided measuring the direct costs of different configurations, rejecting this approach as too cumbersome.

The impact of partnering**{** XE "partnering:impact on cost" **}** was considered by **{** XE "Matthews, J" \f “a” **}{** XE "Tyler, A" \f “a” **}{** XE "Thorpe, A" \f “a” **}**Matthews *et al.* [27], who undertook one case study in which the client, the main contractor and the sub-contractors (although not the consultants) felt that partnering would lead to lower tendering costs. Pasquire**{** XE "Pasquire, C L" \f “a” **}** and Collins**{** XE "Collins, S" \f “a” **}** [28] looked at the effect of competitive tendering**{** XE "competitive tendering:effect on value" **}** on value**{** XE "value:effects of competition on" **}**. They found a lot of wasted tendering costs**{** XE "tendering costs:abortive" **}**, particularly in the case of design and build**{** XE "design and build:abortive tendering cost" **}**.

1.3 Estimates of the Costs of Tendering and Other Components of Procurement

There have been various estimates of the costs of tendering**{** XE "tendering:estimates of cost" **}**. The range of estimates is great due both to the differences in methods of procurements and also to the lack of basic information. There is no doubt that tendering is expensive and each bid must incorporate the cost of failed **{** XE "tendering:costs of failed tenders" **}**tenders [29]. For example, in 1989 it was found in discussions with contractors that they expended of the order of 0.7-1.0% of turnover in the handling of tender documentation [30].

Many researchers have pointed out the wasteful expense of competitive bidding, but little has been done to test the assumption that contractor selection methods influence costs of the tendering**{** XE "tendering costs:influence of selection methods" **}** process. Clients need to be able to make informed judgements on the best value**{** XE "best value" **}** and not the cheapest price in their selection decisions [31]. Current practice makes such informed decisions very difficult to achieve. Cook**{** XE "Cook, A E" \f “a” **}** [32] simply asked contractors how much they spent on tendering, with no attempt to isolate the costs in any systematic way, and got 30 responses varying from 0.25% to 6% of turnover expended on competitive tendering. At a workshop involving the industrial partners for this research project in July 2000, it was reported that building services contractors had calculated that up to 15% of their turnover could be accounted for by “unnecessary” tendering processes, intriguingly close to the 14% associated with “organizing work” reported by Masden *et al.* [26]**{** XE "Masden, S E" \f “a” **}{** XE "Meehan, J W" \f “a” **}{** XE "Snyder, E A" \f “a” **}**.

Private finance**{** XE "private finance initiative" **}** is increasingly popular with governments all over the world, as it reduces the need for them to invest capital in the short term. Grimsey and Graham **{** XE "Graham, R" \f “a” **}{** XE "Grimsey, D" \f “a” **}** [33] estimated that in the UK, by 1997, PFI sponsors had spent more than £30m on bidding for approximately 30 schemes. Experience indicates that “[t]here has been an underestimation by all parties of the length of time to negotiate project agreements” [33: 221]. This forms 1½-3% of the total contract sums involved.

{ XE "tendering costs:estimates of" **}**The best estimates that seem to be available for the overall costs of tendering were reported as from ½-1% of turnover for the simple costs of estimating, right up to 15% if all of the unnecessary costs associated with competitive tendering are taken into account. While these are just estimates, the principle that competition may be organized wastefully is frequently espoused in the literature.

2. Research

2.1 Objectives

{ XE "research:purpose of" **}**There are three types of cost of interest in this research: pre-tendering (marketing, forming alliances, establishing reputations), tendering (estimating, bidding, negotiating) and post-tendering (monitoring performance, enforcement of contractual obligations, dispute resolution). As well as the costs incurred in selling goods and services, costs are also incurred at each stage by the buyer of goods and services. Together, these involve substantial resources which are typically dealt with as overheads, rather than individually costed.

Some of the specific objectives of this research project were defined as:

§ Identify how clients award work and how consultants and contractors obtain work.

§ Explore the structure and magnitude of the costs of the commercial process.

§ Develop a mechanism for measuring the true costs of the commercial process.

§ Use this new data and understanding to quantify the relationship between forms of procurement, types of project and the costs of the commercial process.

2.2 Method

{ XE "research:methods" **}**The research involved qualitative approaches, using individual and group interviews, to develop an understanding of the main issues involved, as well as quantitative approaches, based on questionnaires to the industry. By developing techniques for benchmarking the main indicators of tendering costs, the findings should enable all participants in the construction industry to measure improvements in performance and to identify the most advantageous ways of forming project teams, thus increasing value for money.

The research was carried out in four stages: first, develop and trial data collection methods involving interviews, discussions and feasibility study of various data collection methods; second, two separate surveys of companies, one related to annual business activity and the other to individual bids; third, analysis of the structure of supply chains; fourth, in-depth interviews. The final step was analysis and synthesis of results and findings. Interviews and discussions continued throughout the process. The results of the surveys have already been reported to earlier conferences [1, 2, 3] and the analysis of the interviews will be published later.

3. Surveys

The surveys revealed that the amounts spent on tendering and other aspects of commercial activity vary wildly. Table 2 shows the amounts spent on the aggregated commercial process (all four of the stages from Table 1) by various parties in the process, both in buying and in selling. There is enormous variability here. Moreover, as previously reported, there is simply no correlation with different methods of procurement. The costs vary a lot, but procurement variables are not the most important influence on how they vary.

Table 2: Proportion of annual turnover attributed to commercial processes

Type	Selling (%)	Buying (%)
Developer	0.00	0.43
Public sector client	0.44	1.68
Private sector client	0.00	0.57
PFI/PPP SPV	5.63	0.17
User	2.70	0.28
Main contractor	2.57	1.16
Trade contractor	5.43	1.66
Specialist trade contractor	4.48	1.20
Supplier of bespoke components	8.93	2.11

Table 3 shows cost related to preparing bids, excluding aspects of the commercial process other than bidding. While consultants clearly spend a much larger proportion of their turnover on bidding than contractors do, contractors usually carry out only a small proportion of the work, sub-contracting most of it. It is also interesting the pre-qualification costs are of a similar order of magnitude to bidding costs. While they are presented here according to procurement method, there was actually no correlation to be found between procurement method and cost of bidding. In isolating some of the variable, Table 4 shows that focussing simply on main contractors doing full proposals in non-PFI bids, there is still a huge amount of variability, from 0.07% to 0.8%. If nothing else, these figures reveal that the earlier researchers were indeed correct to conclude that the data are extremely difficult to collect, and that there are too many other variables to isolate the effect of tendering or procurement methods.

Table 3: Average bid cost as a proportion of the value of the work to the bidder

	Full Proposal		Pre-qualification	
Procurement Route	**Consultants**	**Contractors**	**Consultants**	**Contractors**
General Contracting	5.07%	0.81%	3.42%	0.36%
Management	3.06%	0.25%		0.05%
Novated D&B	4.21%	0.21%		
Pure D&B	0.47%	0.80%		1.05%
All procurement routes	4.44%	0.64%	3.42%	0.63%

Table 4: Average bid costs for main contractors in non-PFI full proposals

Sector	Procurement Route	Type of Bid	Project value	Bid cost
Private	Novated D&B	Partnering	£15,000,000	0.12%
Public	Traditional	Preferred / Framework	£15,000,000	0.14%
Private	Novated D&B	Single stage tendering	£1,600,000	0.33%
Private	Novated D&B	Single stage tendering	£1,600,000	0.33%
Private	Novated D&B	Single stage tendering	£220,000,000	0.11%
Private	Traditional	Single stage tendering	£9,000,000	0.07%
Private	Traditional	Single stage tendering	£3,300,000	0.15%
Private	Traditional	Single stage tendering	£7,000,000	0.11%
Public	Traditional	Single stage tendering	£200,000	0.39%
Private	Pure D&B	Two stage tendering	£250,000	0.80%
Private	Traditional	Two stage tendering	£4,000,000	0.20%
Private	Traditional	Two stage tendering	£600,000	0.57%
Average (of summed values)				**0.12%**

4. Interviews

While space precludes a full treatment of the interview data, it is interesting to extract the summary points that came from fifteen structured interview, in which the same set of questions was put to participants from throughout the supply chain:

§ In terms of trustworthiness, interviewees felt that people in construction are no different from those in any other sector; construction has its fair share of rogues. You have to be careful about who you deal with.

§ The most effective form of marketing is word of mouth and repeat business.**{** XE "repeat business" **}**

§ While many people prefer negotiation with firms they can trust, when tendering they get between 3 and 6 firms to bid, although it can be difficult to get serious bids from this many bidders.

§ Every one prefers to be the only player in their market. Nobody likes to be one of a large number of tenderers, but most acknowledge that some competition is inevitable and acceptable.

§ There are many ways of finding a price without competition**{** XE "competition" **}**. Some involve knowledge of the current market rates, others involve cost-plus contracting. In all cases, contractors need intimate knowledge of their own costs.

§ Disputes seem to be rare these days, especially involving contractors. Partnering has played a significant role in the reduction of disputes. Reforms to the legal processes have resulted in fewer litigious episodes.

- § Design competitions{ XE "design competitions" } should not be based on full designs. Partnering seems to be good for getting contractors in early, but it involves a serious commitment and involved negotiations in order to set it up.
- § Consultants sometimes may cause problems, as can contract documentation{ XE "documentation:quality of" }.
- § Because disputes are rare, they are relatively unimportant in terms of the day-to-day business of construction. When they crop up they can be very problematic.

Overall, the interviews revealed that cost is not the most significant thing about tendering and procurement. The costs may indeed be important but the benefits of exploring different ways of working are much more important. There is was a lot talk of increasing value, rather than reducing cost. Thus, a focus on the cost of tendering is probably not the right focus to take. While some processes cost more than others, the benefits from entering into those processes outweighed the extra costs. This was clear from the interviews.

5. Conclusions

This research work has shown that costs of tendering vary a lot, but that they are not proven to be *that* different. Some procurement techniques work better than others, and that is more important than their cost. Although tendering costs can be very high, they are usually a small proportion of the whole cost of procuring work. Indeed, the cost of construction as a whole is only one of many costs incurred by businesses, and there is much evidence that the benefits of well-designed and constructed facilities are much more important than the costs of acquiring them. The worries that people have about costs are equally applicable in all selection and procurements. The interaction with industry has revealed that there are wasteful practices and that these can be avoided. There were strong messages emerging from the research, and they were not about costs: early involvement of designers and builders, reimbursement for tendering costs on cancelled projects, selection on value rather than price, selective tendering lists of only two or three, revealing the identity of competitors and the timely release of comprehensive information. If such practices were adopted by clients, a lot of waste would be removed from the systems of construction procurement.

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The Diffusion of B2B in the Construction Market: Organizational and Technological Determinants

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Abstract

To date the use of electronic tools for the management of business to business (B2B) in construction has been characterized by varying degrees of success, depending on the type of firm, the market in which such a firm operates and the nature of construction production.

A previous study of the top US 400 general contractors has shown that the adoption rate of B2B applications varies widely according to the phases of the supply chain and the type of firms, namely building and non-building contractors. This paper proposes an interpretative model of such a phenomenon. The model builds upon "classic" organizational theories of the firm that are integrated with the transaction cost theory, and its more recent applications to construction, the quasifirm and macrofirm. In the proposed model, the construction industry's varying approach to the opportunities that are offered by e-procurement applications is explained according to several variables, such as the nature of the business transaction under consideration, the size of the buying firm and the market situation. In order to validate the proposed model, a new survey of two different samples of Italian contractors was administered recently by replicating the same questionnaire that was used in the US study. The samples encompass the largest 400 national construction firms and small-medium sized regional firms operating in the area of Bari in Southern Italy. The data collected from the three surveys validate the model substantially, particularly in regard to three of its main dimensions: nature and phases of the transaction, and the national and local market situation.

Keywords: B2B, transaction costs, purchasing, subcontracting.

1. Introduction

The operations within and among construction related firms are characterized by information intensiveness and significant transaction costs (e.g., search, negotiation, contract and administration expenses), given also the fragmented nature of this industry. The use of IT, particularly Internet-based applications, consequently, offers potential benefits in terms of improved information processing capabilities and reduced production time and costs. In this last regard, lower transaction costs produce “liquidity benefits” [1], namely increased market transparency, particularly in regard to price, product availability and/or product selection. Some years ago the capabilities of Internet-based applications were perceived as a big booster of e-commerce growth in construction. A 2000 survey of the UK construction industry forecasted that about 50% of business transactions would have been based on e-commerce applications in 2005 [2]. Such “unrealistic expectations” were lowered to 22% one year later [3], a figure that is still too optimistic considering current market trends. Similar disillusion could be observed in the US and other European markets. Overall the use of e-commerce in construction has been lower than expected. Currently the extent of its adoption varies, depending on the type of purchased construction input. This paper aims at explaining some of the reasons behind the disillusion with e-commerce and different adoption rates of these applications.

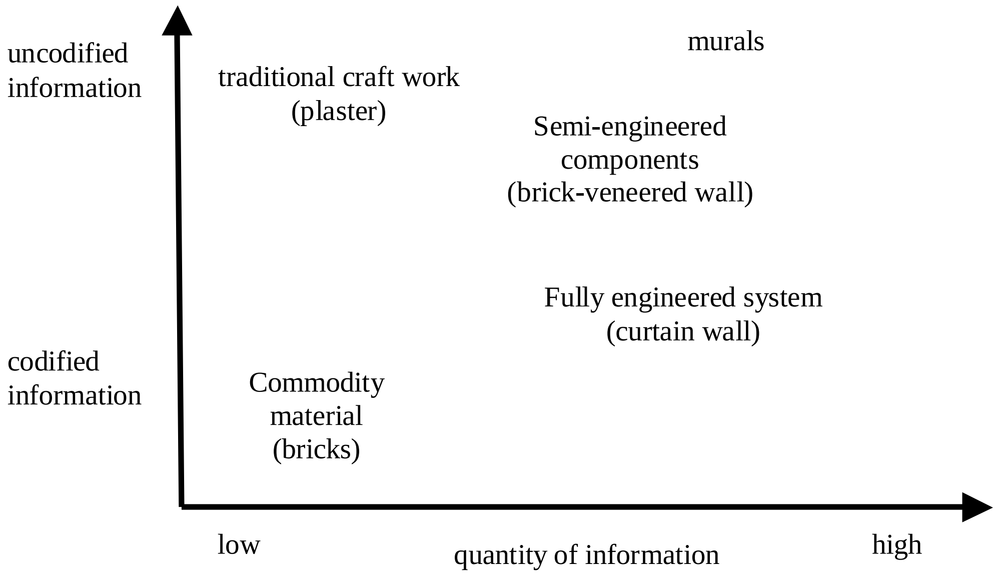
2. Transaction costs in construction procurement

The transaction cost theory builds upon the issue of the boundary of the firm that was addressed by Coase [4]. The internal and external transactions of a firm must be governed and give rise to costs that vary according to a given firm’s organization and its relationship with other firms. As it was remarked by Williamson [5], “the transaction cost approach to the study of organizations has been applied at three levels of analysis. The first is the overall structure of the enterprise… The second or middle level focuses on the operating parts and asks which activities should be performed within the firm, which outside, and why… The third level of analysis is concerned with the manner in which human assets are organized”. At any of these three levels, each contract is necessary incomplete, given the bounded rationality and opportunistic behavior of the transacting parties [6], [7]. It can be concluded that “transaction cost economics studies how trading partners protect themselves from the hazards associated with exchange relationships” [8]. This last definition appears to be particularly suitable for addressing the type of transactions considered in this study: the purchase of construction supplies and services by general contractors. Construction firms, in fact, buy materials and components in case of self-performed work or/and, more often, rely on the services of specialized trade contractors. As pointed out by Eccles [9], the high rate of subcontracting in construction is driven by the small diversification degree by firms, the complexity and non repetition of projects, and demand uncertainty. Asset specificity is another important factor that characterizes the governance mode of transactions [6] [10] [11]. Table 1 shows the range of possible production options that a general contractor faces in the construction of a building facade. By internalizing (make option) or externalizing (buy option) portions (or the entirety) of production, the contractor establishes the boundary of his firm, so to control its “technical core” [12]. A similar range of options can be found in the other composing parts of a building or facility.

Table 1. Range of inputs for the construction of a building facade

	Design	**Fabrication**	**Assembly**	**Delivery**	**Erection**	
Tools/machinery				**X**	**X**	Crane, scaffolding
Base material				**X**	**X**	Mortar, caulking
Standard component			**X**	**X**	**X**	Brick, standard window
Customized component	**X**	**X**	**X**	**X**	**X**	Wall panel, special window
System	**X**	**X**	**X**	**X**	**X**	Exterior wall and window system

US statistical and survey data [13] [14] show that the boundary of the firm varies depending on the type of construction market. In building construction the rate of subcontracting is significantly higher than in that of non-building construction. Such a difference can be explained in terms of diverse technical cores set by building and non-building contractors whose decision is driven by the type of undertaken projects and markets in which these firms operate. It should be noted that the information flows (and therefore transaction costs) that are related to the various purchasing situations, as shown in Table 1, vary in terms of quantity of information processing and codification level. The higher the required craftsmanship of a category of work to be purchased, the more its transaction needs the exchange and sharing of uncodified (or less codified) knowledge and information. This relationship, limited to the example of a building facade, is shown in Figure 1. The successful transmission and sharing of uncodified information presents obvious difficulties that can be alleviated through repetitive business transactions between the same parties over time. In this regard asset specificity induces firms to establish long-terms relations that have been termed quasi-firm [15] or macrofirm [16]. As the level of codification of the knowledge to be exchanged decreases, so the need for developing a common language (idiolect, in semantics terms) [17] increases between transacting parts. The efforts for sharing a common language and understanding are like an investment whose convenience results from repetitive transactions between a general contractor and his suppliers and subcontractors. To a certain extent, all symbolic languages are born as idiolects. Some are shared among many parties (e.g., the representation of an electrical system), others are shared by fewer parties (e.g., the terminology used for the chromatic



and texture continuity of a stone veneered curtain wall). The extreme is represented by the idiolect that expresses the tacit knowledge of the craftsman that can be communicated only through its application.

Figure 1. Different information requirements of the construction of a building facade

According to Nonaka and Konno [18] “tacit knowledge is highly personal and hard to formalize, making it difficult to communicate or share with others”. Lack of information codification, in addition, gives rise to ambiguity and therefore leads to possible opportunistic behavior and information asymmetries in spot transactions, a hazardous situation that is lessened only with repetitive business transactions between the same parties. The need for a shared idiolect and risk of opportunistic behavior are two of the main determinants of the phenomenon of the quasi-firm [15] [19]. In subcontracting, particularly in building construction, long-term business relationships are needed for protecting general contractors from the hazards associated with exchange relationships.

3. The management of purchasing process

The process of managing the purchase of supplies or subcontracting services in construction generally encompasses seven specific steps [20], as shown in Figure 2. The undertaking of each step entails the generation, transmission and management of information whose quantity and level of codification varies significantly according to what is transacted. Each information process results in costs that can have a deterministic nature, such as those incurred for product identification or payment, or a probabilistic nature, such as those incurred for quality control and acceptance, as they relate to “quality shortfalls, ex-post bargaining over surplus, litigation, hold-up costs and wasted investments”[11].

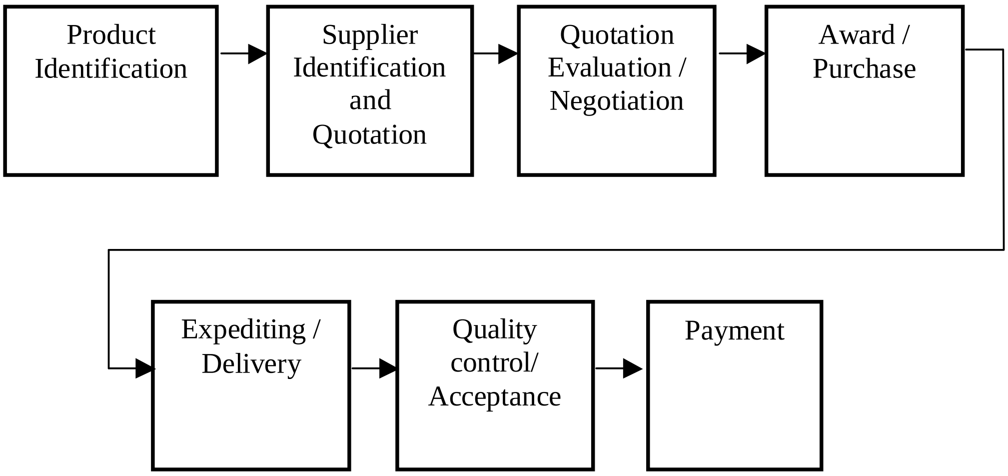


Figure 2. The steps of the purchasing process

When commodities (e.g., base materials or standard components) are considered, their purchasing process is characterized by: a) a reduced amount of information flows with high levels of codification. In this case, Internet-based applications can lower transaction costs significantly. b) a decreased risk of contractual hazards (for the small amount of exchanged information and its highly codified nature) and, therefore, of opportunistic behavior (also for the presence of liquidity benefits).

When subcontracting or customized components are considered, their purchasing process is characterized by: a) an increased amount of information flows with varying extents of codification. In this case, Internet-based applications offer opportunities for lowering the cost of the information process (considering also its high volume), provided that the latter is based on shared idiolects. b) an increased risk of contractual hazards and opportunistic behavior. This situation leads to the persistence of using proven and known subcontractors or suppliers, independently from the possible advantages of shared idiolects.

4. Potential impact of Internet applications

Business to Business (B2B) applications can impact any of the seven steps of the purchasing process shown in Figure 2. According to Ronchi [21], "the Internet could streamline an inefficient procurement process by removing the manual, paper-based, administrative and bureaucratic elements inherent in traditional purchasing systems". The possible impact of these technologies on purchasing process and procedures varies. We can hypothesize three main scenarios and related intermediate situations. These scenarios are used as hypotheses to be verified with the presented empirical study.

a) The first scenario encompasses the use of Internet-based technologies (e.g., e-mail and on-line catalogues) for identifying and contacting possible suppliers/subcontractors (with whom a contractor had usual past business relationships, depending on the risk of contact hazard) and exchanging information that is codified into a shared idiolect. For example, when the purchase of craft based work is considered, a buyer may use Internet technologies to locate and solicit proposals, finalize the purchase order and process payments, while at the same time the traditional in-house protocols for proposal evaluation and quality control/acceptance remain the same. In practice the Internet technologies are simply a new tool for managing existing established information protocols.

b) The second scenario encompasses the use of Internet-based technologies, as integrated into an Enterprise Resource Planning (ERP) or existing in-house purchasing procedures. In this case, all information flows have been codified into an idiolect shared with potential (and generally usual, depending of the risk of opportunistic behavior) suppliers. The traditional purchasing procedures are modified and integrated into the in-house ERP or other accounting protocols. The Internet technologies are still a tool for improving the efficiency of purchasing efforts.

c) The third scenario encompasses the use of the Internet for purchasing products and/or services on line and the participation as a buyer in reverse auctions or public marketplaces. The purchasing process is almost completely delegated to the portal. In the case of reverse auction, the choice of the supplier is generally left to and managed by the portal software (usually on the lowest price below a given monetary threshold). The reduced risk of incomplete contracts and of (consequent) opportunistic behavior facilitates the achievement of liquidity benefits, for the increased number of possible (even if little known) suppliers. In this case, the purchasing protocol is completely modified, similarly to what happen when an air ticket is bought through the services of Travelocity or Expedia.

This interpretative model of the possible impact by Internet-based technologies on the purchasing procedures by contracting firms is shown in Figure 3. To verify the above - mentioned scenarios, a questionnaire survey was designed and administered to three different samples of general contracting firms, as follows.

1) A sample of 460 US firms that includes the top 400 according to the 2002 *Engineering News Record* ranking.

2) 2) The top 111 Italian firms according to the 2003 ranking by the magazine *Il Nuovo Cantiere*.

3) A sample of 98 firms that operate in the region of Bari, in Southern Italy. In terms of yearly sales, these firms are much smaller than those of the two other samples, as shown in Table 2.

The survey contained 32 questions broken down into three sets of concerns. One set addressed the use extent of the following Internet-based technologies by the considered firms.

a) Use of the Internet to search possible suppliers and exchange information until the issuance of purchase orders.

b) Use of on-line purchasing protocols and whether they were integrated into a firm's ERP.

c) Purchasing through on-line catalogues.

d) Purchasing through reverse auctions and public and private e-marketplaces.

Tables 3 and 4 illustrate the results of the listed set of questions. The survey results show interesting patterns. Although the use index of IT in Italy is approximately 1/3 lower than that in the USA, the first two samples of surveyed firms show similar orientations to using the considered Internet-based technologies. Both the US and Italian contractors (second sample) have a decreasing rate of adoption or interest in the most advanced Internet-based technologies, as hypothesized earlier in the paper. E-mail is frequently used (65-70% of cases) for exchanging information with suppliers. There is significant integration of these information flows into existing corporate management information systems (50-60%). The use of on-line purchasing is substantial (35-40%), while that of reverse auctions and e-marketplaces (less than 30%) is still a limited one.

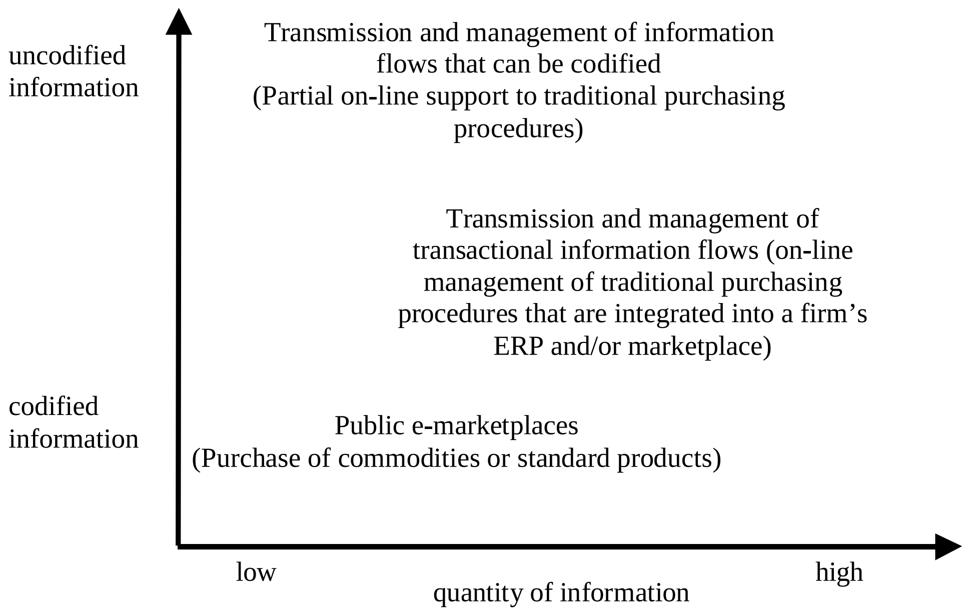


Figure 3. Possible impact of Internet-based technologies

Table 2. Characteristics of the surveyed firms

	USA	**Italy**	**Bari**
Sample	460	111	98
Respondents	56	37	32
2003 sales[1]	$ 626.000.000	$ 339.000.000	$ 4.100.000
% building firms	71%	65%	69%
% non building firms	29%	35%	31%

[1] 2002 for the US sample

Table 3. Results of the surveys (I)

		USA	Italy	Bari
Use extent of e-mail for communications with suppliers	Planning	16%	16%	6%
	In use	49%	58%	12%
Use extent of integrated management of information	Planning	27%	12%	7%
	In use	32%	39%	4%
Use extent of on-line purchasing	Planning	8%	27%	3%
	In use	33%	17%	17%

Table 4. Results of the surveys (II)

		USA	Italy	Bari
Use extent of reverse auctions and e-marketplaces	Planning	10%	10%	0%
	In use	18%	18%	0%
Use extent of on-line purchasing of commodities	Planning	5%	24%	1%
	In use	45%	24%	19%
Use extent of on-line purchasing of engineered products and subcontracting	Planning	6%	21%	0%
	In use	29%	12%	19%

The use rate of the four considered technologies appears to be significantly affected by the size of firms, as can be seen in the responses by small firms (Bari region) and medium-large firms (USA and Italy). As far as purchasing through online catalogues is concerned, this practice is adopted (or in planning for adoption) more often for standard products or commodities) (48-50%) than for engineered components or subcontracting (33-50%). The second set of questions pertained to the major perceived obstacles to the adoption of e-commerce. On a Likert scale (1-5), the following two reasons were ranked as most important by respondents: 1) Reluctance among subcontractors and suppliers (3.9 USA; 3.3 Italy; 3.8 Bari). This result was expected, considering the generally small size of specialized trade firms. 2) Preference for proven subcontractors and suppliers (3.5 USA; 2.9 Italy; 4.0 Bari). This orientation confirms that as the complexity and need for processing large amounts of uncodified information increase in a business transaction so does its asset specificity. The possible liquidity benefits are not as convenient as the benefits of long-term collaboration, e.g., reduced risk of hazards associated with exchange relationships with unproven partners.

5. Differences between building and non-building contractors

All the considered surveyed samples include building and non-building construction firms (e.g., civil engineering), whose characteristics are shown in Table 5. Non-building contractors usually self-perform more work; therefore, and differently from building contractors, they purchase more basic materials and components (i.e., commodities) to be installed by their in-house workforce. This type of production arrangement is reflected in their more frequent recourse to reverse auction and e-marketplaces, as shown in table 6. As the complexity of a business transaction increases (e.g., the purchase of customized components or subcontracting services) the capabilities of reverse auctions and e-marketplaces become less useful. In this regard, the surveyed contractors indicated that the inability of current e-commerce software in meeting the procurement needs of customized components or subcontracting was perceived as a major obstacle to the adoption of these technologies (on a Likert scale: 3.6 USA; 4.4 Italy; 3.3 Bari).

Table 5. Subcontracting rate by building and non-building contractors

		USA	Italy	Bari
Average yearly sales	Building	$ 447.000.000	$ 153.000.000	$ 3.500.000
	Non-building	$1.074.000.000	$ 678.000.000	$ 5.400.000
Subcontracting (%)	Building	76%	65%	62%
	Non-building	29%	48%	30%

Table 6. Use extent of reverse auctions and e-marketplaces

		USA (B)	USA (NB)	Italy (B)	Italy (NB)
Use extent of reverse auctions and e-marketplaces by building (B) and non-building (NB) contractors	Planning	10%	10%	9%	11%
	In use	11%	37%	15%	22%

6. Conclusions

The survey results appear to confirm the original hypotheses (based on the transaction cost theory) of the study.

- The use of the Internet (i.e., e-mail) for the information handling of some tasks of the purchasing process is quite diffused, because it offers savings in terms of transaction costs and it does not alter existing purchasing procedures.

- The integration of e-commerce procedures into corporate ERPs is not diffused. Only large firms can afford the significant investments of changing purchasing and accounting procedures, IT systems and personnel training.

- Online purchasing is practiced for the procurement of basic materials and products rather than for engineered or more complex products.

- The use of reverse auctions or e-marketplaces is still a marginal phenomenon. These applications tend to be used by non-building contractors that self-perform a large portion of their work and purchase commodity-like products.

- The procurement of complex products and subcontracting is a transaction that induces contractors "to invest" in repetitive or continuous business relations with proven partners. This type of transactions is characterized by a high level of asset specificity, given the challenge of exchanging a large amount of (often) uncodified information successfully and the possibility of opportunistic behavior.

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Economic Efficiency of Contractors

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Abstract

Efficiency studies of the construction industry at the micro level are few and far between. In this paper information on multiple outputs is utilized by applying Data Envelopment Analysis (DEA) on a cross section dataset of Norwegian construction firms. Bootstrapping is applied to select the scale specification of the model, estimate and correct for the sampling bias. A new contribution is to use the inverse of the standard errors (from the bias correction of the efficiency scores) as weights in a regression to explain the efficiency scores. Several of the hypotheses investigated are found to have statistically significant empirical relevance. The most efficient companies were characterized by a high average wage per hour, a low share of apprentices, a low concentration in the product mix and a high number of hours worked per employee. Contractors with a total sales lower than 100 mill. NOK seems to operating at a suboptimal scale.

Keywords: Construction industry, DEA, efficiency, bootstrapping, weighted two stage.

1. Introduction

This study is part of the research project “Productivity in Construction” at the Norwegian Building Research Institute (NBI) financed by the Norwegian Research Council. Low productivity growth of the construction industry in the nineties (based on national accounting figures) is causing substantial concern in Norway. To identify the underlying causes investigations at the micro level are needed. However, efficiency studies at the micro level of the of the construction industry are very rare. [2, 14]

The objective of this study is to analyze productive efficiency in the Norwegian construction industry. A piecewise linear frontier is used, and technical efficiency measures [12] are calculated on cross section data following a DEA (data envelopment analysis) approach [7].

One reason for the small number of efficiency analyses of the construction industry may be the problem to “identify” the activities in terms of technology, inputs and outputs in this industry. It is well known that there are large organizational and technological differences between building firms. Even when the products are seemingly similar there are large differences in the way projects are carried out. For instance some building projects use a large share of prefabricated elements, while other projects produce almost everything on the building site. This often happens even when the resulting construction is seemingly similar. It is interesting to note that projects with such large differences in the technological approach can exist at the same time. Moreover, the composition of output varies a lot between different construction companies so the definition of the output vector may also be a problem. Thus to capture such industry characteristics, a multiple input multiple output approach is required.

A debated issue is whether an efficiency analysis should be carried out at the project level or at the firm level. In many ways it is more natural to think of the project level as the decision making unit (DMU) in this industry. In addition it might be easier to find relatively homogenous projects than firms. A third aspect is that when one tries to explain any efficiency differences it is likely that there are bigger differences between the projects than between the firms when it comes to choice of construction technology. However, the required data for studying productivity at the project level is not (yet) available, so the firm level is the only available level for an efficiency study of the construction industry at the micro level in Norway. Collecting data at the project level is part of the research within "Productivity in Construction."

It should be noted that the firm level should not necessarily be seen as a higher aggregation than the project level. It is not unusual that a project in this industry is larger than any of the participating firms, and quite often a large project can span two or three accounting years.

The layout of the rest of the paper is according to the following plan. Section 2 gives a brief overview of the methods used in this paper. The main ideas are explained, notation is introduced, and the most central references are listed. Section 3 deals with how the data used in this paper was collected and processed. In Section 4 results of the DEA efficiency calculations are reported, and the effects of correcting the efficiency scores for bias is shown. Some interesting hypothesis that might explain some of the differences in the firms' efficiency scores are investigated in Section 5. Section 6 rounds off the paper with a summary.

The efficiency scores in this paper are calculated with DEA and then bias corrected with bootstrapping. The model selection is also done with the help of bootstrapping, while the statistical power of the stage two regression is increased by taking advantage of the standard errors of the bias corrected efficiency estimates.

2. The Data

In 2001 the Norwegian building industry consisted of about 34 500 enterprises, and employed about 132 500 persons (about 10 percent of the Norwegian labour force). From 2000 to 2001 there was an 8.7% growth in turnover and 7.4% growth in employee compensation. The efficiency calculations in this paper must be seen in the light of the fact that the industry experienced strong growth in the year under investigation.

The primary data on the building enterprises is collected on a yearly basis by Statistics Norway. All the firms in the dataset used in this paper have a NACE code of 45.211. This means that at least 50% of their production value is in the category "construction of buildings."

The sample collected by Statistics Norway consists of all enterprices with more than 100 employees, and a sample of the smaller enterprices. The sample contains at least 30% of the total emplyment in the NACE 45.211 subgroup.

Based on data for each building enterprise we have created a cross section database on production and resource usage for the most recent year available (2001). A rather extensive set of input and output data were available based on annual company accounts and the structural survey conducted by Statistics Norway. After extensive discussions with Statistics Norway and sector experts the input-output specification was selected. Output is measured as value split on three different categories: Residential buildings, Non-Residential Buildings, and Civil Engineering. The three inputs are External Expenditure, Labor, and Real Capital. Details are laid out in Section 3.

3. Data

3.1 Descriptive Statistics for the Primary Dataset

The resource usage of the building entrepreneurs is captured by three inputs (the three first columns in Table 1): External Expenditure includes materials, subcontractors, energy, transportation etc. Labor in Man-Years is a measure of the labor usage. Real Capital is a measure capital service based on the use of production equipment, machines, etc. It is calculated from rental expenditures and depreciation. The last three columns of Table 1 contain summary statistics on the production of the building entrepreneurs. Residential is a measure of the sales value of the residential and recreational buildings. Non-Residential is a measure of the sales value of other buildings, such as office buildings and institutional buildings (schools, prisons, hospitals etc). Civil Engineering measures the sales value of constructions such as roads, tunnels, harbors, etc.

Because of the data filters all three inputs have strictly positive values, and the lowest value for Labor in Man-years is 1. The lowest value for all the three product variables is 0, but all firms have a strictly positive sum of output values. Construction is clearly the output with the lowest number of strictly positive output values, and is also the variable with the largest CV-number. Concerning the size distribution, 39% of the firms use less than 10 man years,

Table 1: Descriptive statistics for the primary variables (342 observations after the data cleaning).

	EXTERNAL EXP.	LABOR IN MAN-YEARS	REAL CAPITAL	RESI-DENTIAL	NON-RESI-DENTIAL	CIVIL ENGINEERING
Minimum	18.0	1.0	2.0	0.0	0.0	0.0
Maximum	4 083 634.0	2 950.0	23 9847.0	1 597 609.0	2 556 175.0	1 170 239.0
Average	44 968.6	38.3	1970.1	27141.4	32 160.2	5 688.4
St.dev	233 063.7	167.2	13 655.7	113 635.8	147 942.9	66 574.4
Count >0	342	342	342	301	218	31
CV	5.2	4.4	6.9	4.2	4.6	11.7

CV is the Coefficient of Variation. It is defined as the ratio of the standard deviation and the average.

47% use between 10 and 50 man years, 11% use between 50 and 100 man years, while 5% use more than 100 man years. The average firm has close to 41 employees and uses 38 man years.

4. Estimating the Efficiency Scores

In Figure 1 the bias corrected efficiency scores are sorted pairwise with the uncorrected efficiency scores. This allows us to compare the efficiency score for each individual DMU before and after the bias correction, and also examine whether there is any systematic difference when it comes to how the sampling error influences firms of different sizes.

Inspection of Figure 1 confirms that all of the large construction firms have a large estimated bias. This is often the case, because the sampling error typically hits the large firms harder in a VRS model. The tendency is relatively strong, as shown by the regression on estimated bias versus production volume (and its square) below. Figure 5 is quite instructive because it shows the big difference that the bias correction does with the very large units. This strongly suggests that analyzing scale economies without checking for sampling bias in DEA can give misleading results. In addition, since the large firms very often contribute a large share of the production and resource usage of an industry, measures of efficiency at the aggregated level will tend to be more distorted.

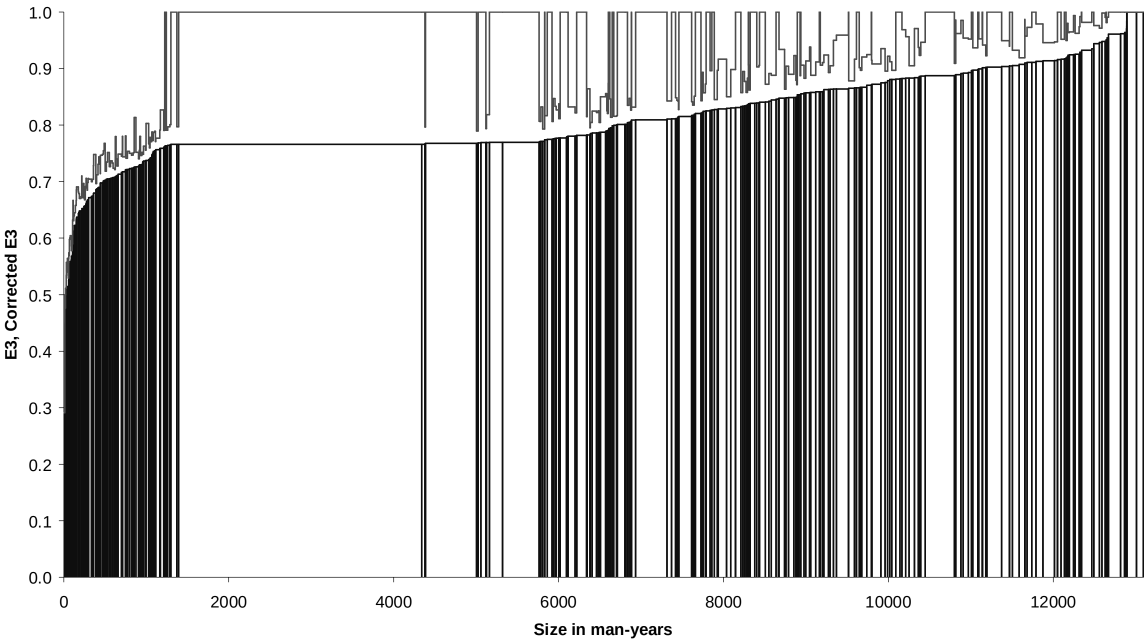

Figure 1: Efficiency diagram of bias corrected and uncorrected efficiency scores (E_1), pairwise sorted.

Table 2 displays the descriptive statistics for the VRS (E_1) and CRS (E_3) efficiency scores, with and without bias correction.

Table 2: Descriptive statistics for VRS and CRS efficiency scores, with and without bias correction.

	Obs	Averag e	Stdev	Min.	Max
E_1 uncorrected	342	0.848	0.136	0.291	1
E_3 uncorrected	342	0.687	0.167	0.255	1
E_1 biascorrected	342	0.785	0.116	0.277	1
E_3 biascorrected	342	0.615	0.137	0.235	1

5. Efficiency and Productivity Explained

The efficiency estimation in Section 4 revealed large differences among the firms when it comes to technical efficiency and productivity. In this section, different hypotheses that might "explain" these differences are developed and tested in a stage two setting for empirical relevance. In addition to including the efficiency scores from stage one, it is argued in Section 2.4 that the certainty level for each of the observations should also be taken into account. It should however be noted that the available data is not sufficiently detailed to give a clear indication of why some firms appear to be much more efficient than others. Some hypotheses are associated with statistically significant parameter estimates, but these should mainly be viewed as indications of interesting topics for further research.

5.1 Constructing Hypotheses Based on Existing Theory and Knowledge of the Industry

The hypotheses developed below were generated based on knowledge about the industry and given by the limited availability of data.

a) **Wage cost per hour.** Higher wages can attract the best workers. In addition, piecework contracts can lead to higher average wages. One might suspect that this factor is closely related to the hypothesis (d) since overtime is also associated with a higher hourly pay. However, a regression with Wage Cost per Hour explained by Hours Worked per Employee gets an R2 of only 0.03, so there should be no problem with multi-colinearity.

b) **Apprentices.** This is defined as the number of apprentices relative to the number of employees. The idea is that the most efficient companies have low shares of apprentices. The reason is that we expect the companies with high shares of apprentices to have higher costs and lower production since apprentices are under training, which should imply lower productivity of the apprentices and also man-hours used by other employees to offer them guidance. On the other hand, a history of having a high number of apprentices could give good access to high quality human capital in the long run. The hypothesis is nevertheless that the total effect of a high number of apprentices is reduced efficiency.

c) **Product Mix.** This is measured, using the Herfindahl index, by the quadratic share of the sales of the companies divided between the seven underlying markets. The expectation is that the most diversified firms are more efficient since they have the option of using their resources in the most attractive market depending on short term business cycles. It should be mentioned that the business cycles in the construction industry can change very fast. In addition, there is a possible selection effect since this variable might pick up that the "best" firms get contracts outside of their key markets.

d) **Hours Worked per Employee.** The hypothesis is that the firms with high numbers of hours per employee are more efficient. The reasoning is that these firms get more efficient production by the use of overtime. It might be that some employees work better under a certain degree of pressure. It could also be that the best workers choose their employer based on the opportunity to work overtime. An additional possibility is that the repetition effect is positive and that the use of overtime allows for longer repetition sequences.

e) **Located in Oslo.** Oslo is the capital and the largest city of Norway, and a pressure area. Housing prices are usually higher in the Oslo area, and the way efficiency in this paper may be influenced by this price effect.

It would have been interesting to follow up Albriktsen and Førsund [2] and examine if the amount paid to subcontractors is correlated with efficiency. However, the quality of the data at hand is too low (a large number of firms have reported a value of zero even when this is not believable).

5.1 Do the Suggested Hypotheses Have Empirical Relevance?

The regression models used below are weighted least squares and OLS (for comparison). The weights in the weighted regression are the inverse of the squares of the estimated standard errors from the bootstrap simulations. The motivation is to put low weight on an observation when there is low certainty of its real value. The regression calculation was carried out in Stata 7. This statistics package (and many others) has built in support for assigning *a priori* (in a sense) known weights to the observations.

Table 3 shows the results from an ordinary OLS regression (left part of the table) and a weighted least squares regression. A truncated regression was also computed (with right truncation at 1) but the results were as good as identical to those laid out in Table 3. The coefficients with statistically significant parameter estimates (at the 5% significance level) are highlighted with bold fonts. A higher number of the parameter estimates are statistically significant in the weighted regression compared to the OLS regression. The p-values are also lower in the weighted regression, with the exception of the Intercept estimate which has a slightly lower p-value in the OLS regression.

Table 3: Weighted and unweighted regression.

Explanatory variables	**Unweighted (R^2=0.14)**			**Weighted (R^2=0.26)**		
	Coef.	t	P>|t|	Coef.	t	P>|t|
Wagecost per hour (a)	**0.0012**	**6.69**	**0**	**0.0019**	**9.14**	**0**
Share of apprentices (b)	-0.0802	-1.15	0.25	**-0.1487**	**-2.18**	**0.03**
Product mix (c)	**-0.0478**	**-2.04**	**0.042**	**-0.0880**	**-3.83**	**0**
Hours worked per employee (d)	**0.0001**	**2.64**	**0.009**	**0.0001**	**4.02**	**0**
Oslo (e)	-0.0106	-0.49	0.622	0.0093	0.32	0.752
Intercept	**0.4349**	**5.91**	**0**	**0.2456**	**3.1**	**0.002**

If we believe in the statistically significant parameters from the weighted regression (Table 3), then the most efficient construction companies are characterized by:

- High average wage per hour
- Low numbers of apprentices
- Low concentrations in product mix
- High numbers of hours worked per employee

Not statistically significant:

- Located in Oslo

5.2 Productivity and Scale

A bootstrapped scale specification test rejected the null hypothesis that the correct model specification was CRS. However, even when we choose to believe that the true production function exhibits VRS we can find use for the CRS measure, and interpret it as productivity. This can be used as a measure of to what degree the sector has an efficient structure.

In Figure 2 the maximal value plotted on the horizontal axis is 1,200,000. The intention is to zoom in on the range where there seems to be most interesting systematic tendencies in the simultaneous distribution of average productivity and scale. It seems that the average productivity of the construction firms increases until the size is about 100 millions (NOK). There does not seem to be any systematic change after this value is reached. However, there are not many construction firms with production values much higher than 100 millions NOK in the sample, nor in the population of all Norwegian construction firms.

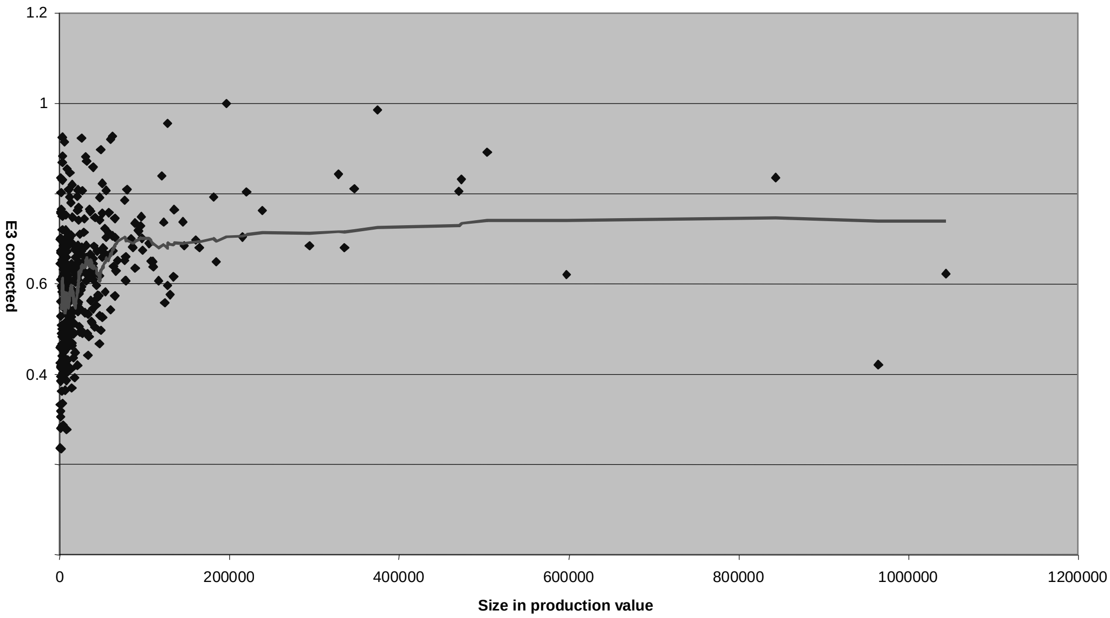

Figure 2: Scale chart showing Production Value and E3 (range 0-1’200’000).

6. Conclusions

This paper concerns using DEA to investigate the efficiency of Norwegian building firms. Large differences in the efficiency and productivity scores were discovered. One important lesson that can be learned from this application is the danger of taking the efficiency scores from uncorrected DEA calculations at face value.

Based on a scale specification test, a variable returns to scale specification was selected. A scale chart indicated that firms with total production values lower than 100 mill. NOK might be operating at a suboptimal scale level.

The differences in the efficiency scores may be explained by environmental and managerial variables. Such variables have been tried in a two stage approach. A new contribution is the demonstration of how one can use the standard errors from the bias correction in stage one to improve the power of the regression model in stage two.

Five possible explanations were examined for empirical relevance, and four of them were found to be statistically significant in a multivariate weighted regression setting. More detailed data would be necessary before strong conclusions can be made, but there are indications that the most efficient building firms are characterized by high average wages, low numbers of apprentices, diversified product mixes and high numbers of hours worked per employee.

One possible problem when it comes to interpreting these results is the one of unbalanced selection. It might be that the firms that were removed from the dataset belong to a different population when it comes to the inefficiency distribution. There might be a positive correlation between entering correct data and the true technical efficiency of the units included. If the units included in the dataset are on average more efficient than the average in the population, then the overall picture of the efficiency of the industry is too optimistic.

Concerning further research a possible extension is to study time series by including data for other years. The Malmquist index could be used to decompose the productivity development of each firm into frontier shift and catching up. The relationship between productivity change and entry / exit analysis could provide additional insights.

If data on the project level became available, it could be investigated whether the findings in this paper have empirical relevance on project level data.

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Is the A/E Consulting Market Shifting from Equilibrium to Distortion?

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Abstract

The Finnish Competition Authority (FCA) concluded in the early 90's that the minimum tariff driven by the Union of Finnish Architects (SAFA) was in breach of the competition rules. In June 2004 the European Commission made a similar decision for the Belgian Architects' Association. After the deregulation the A/E cost in Finland declined due to several factors including the recession in the early 90's. Who benefited by the deregulation is still under discussion. The article compares deregulation's outcome to peer cases as the recent taxi license liberation in Sweden, which led to a rapid 35 % price increase and a quality improvement. The latest service sector productivity figures by Statistic Finland are negative. Several indicators show that rivalry action is increasing. At present all A/E firms utilize ICT and the efficiency improvement is considered self-evident. However, reliable data on the improvement is hard to find. In addition, even in the mature U.S. market, the A/E industry is fragmented and has few economies of scale compared to process engineering. The objective is to understand how the deregulation changes the A/E market from two viewpoints: the competitive forces as the shifts in demand and supply and secondly from the productivity and efficiency viewpoint. The methodology is divided into three categories, national statistical analysis, comparable case analysis (peer groups) and comparable method analysis (theories).

There are two main findings. The outcome of the deregulation is not automatically what expected although the quality deterioration is indirect. Secondly, the preliminary data on A/E industry's productivity improvement due to the "lean consulting" and ICT is not so evident. In addition, no evidence supports the hypothesis of economies of scale increasing profitability in A/E consulting. A/E market can either adapt to the free competition or respond to the market failures. By the free market theory a perfectly efficient market should be deregulated as far as possible, however for the society it may result as a lose lose situation, whereas licensing policies and/or quality measurement procedures shift the equilibrium to the other direction. The question is how to create a win-win situation. In a supply-driven economy R&D is seen as a driver. The traditional Design/Bid/Build method is being replaced by CM. Research projects and designer selection methods for buying and producing A/E consulting services and allocating planning resources efficiently will become the key success factors of the future construction business.

Keywords: Competitive forces, demand theory, economies of scale, equilibrium, deregulation

1. Introduction

In June 2004 European Commission concluded that the Belgian Architects' Association's fixed fee scale known as Ethical Standard 2 since 1967 was a restriction of competition even though it didn't directly infringe the article 81 of Treaty of Rome [4] stating that associations' decisions restricting trade between member states are prohibited. The decision presents European Commission's tightening grip on free competition. Since Finland, Sweden and Austria joined the Union in 1995, the competition authorities have steadily increased co-operation. The French Competition Authority and the British Office of Fair Trade have been scrutinising similar fee systems. Furthermore the Finnish Competition Authority (FCA) ordered in October 2004, that the Finnish Architects' Association (SAFA) must terminate its Competition Act, because it impedes the competition in the A/E market and complicates new architects' activities and limits the development of architectural competitions.

Since the deregulation a continuous argument about the pros and cons of free competition has been going on. The minimum tariff was a percentage of the total estimated construction cost and the percentages were categorized by the project size and planning difficulty. SAFA argued that the deregulation lowered the quality of the design. After the deregulation the A/E cost for the contractors declined but so did also the entire construction business dropping from 60 million cubic meters to 25 million in four years. A clear distinction between the deregulation's and recession's impacts is not easily drawn.

Who benefits most by the deregulation is permanently under discussion. For understanding the outcome on A/E consulting some comparable cases on deregulation are evaluated. In the early 90's the Swedish government liberated its oligopolistic taxi licence system. The taxi service as a product is not directly comparable with the A/E service, but the case provides general data on deregulation's impact on pricing and service quality (availability). The deregulators seem to expect that an increase in competition automatically intensifies the use of resources and thus benefits the end user, the customer. A comprehensive economic analysis has been has carried out by the Swedish government. The analysis covers also the simultaneous liberalisations of the Swedish railways, post office and telecommunication.

The Finnish market has also experienced comparable deregulations. The heavy licence fee system on TV-commercials was released in year 2002. The Finnish TV-commercial business had been a monopoly until it was released in year 1996. The generic substitution in the medicine market was introduced in the Finnish Health Insurance Act in April 2003 [13]. By the new practice a prescribed medicinal product is substituted in a pharmacy by the cheapest generic alternative. Nevertheless the consumer doesn't seem to be the beneficiary side despite the government's expectations.

The latest service sector productivity figures by Statistic Finland, that include the A/E sector, are negative. Economists define the productivity concept as the ratio of total input of resources and total output of the product [7]. However, because the input in A/E consulting consists mainly of labour and the output of the consultant's net sales, the productivity concept differs from the traditional manufacturing business. As the traditional Design/Bid/Build method is being replaced by CM method, A/E consultant's value creation potential and further its planning resource allocation becomes critical. Secondly the impact of ICT is contradictory. During the IT hubris the expectations exceeded the reality, but at present all A/E firms utilize ICT technology. The efficiency improvement is considered self-evident, but studies on basic 2D design (e.g. AutoCAD, ArchiCad, All Plan) efficiency are hard to find. The majority of the studies focuses on "fashionable" 3D and even on 4D, but gives a little information on actual efficiency improvement. Thirdly, from the service management's viewpoint, the internal and external efficiencies have to be understood as separate concepts.

As "lean" production increases, enterprises are trying to achieve economies of scale through a growing number of mergers and acquisitions instead of growing conventionally. Outsourcing has been another trend. Although it concerns more manufacturing, the service sector is following and outsourcing has been carried out also in A/E business. Furthermore, Civil engineering and architectural service markets are considered fragmented compared to e.g. the process engineering firms. Does it a proof that process engineering firms are better in utilizing the economies of scale or is it just a result of the market structure? In addition, the report of the Construction Task Force headed by Sir John Egan in 1998 argued that given the existing level of resources in construction it should be possible to increase productivity even by 10 % [11]. The report argued that the society cannot for the moment get more productive with the present quantity and quality of its resources. The lean production concept is leading to lean construction, but is it or should it lead to too lean consulting?

2. Objectives

The objective is to understand how deregulation and the shift in competitive forces have changed A/E consulting market structure and how the changes relate to A/E consulting productivity. The analysis has two main viewpoints: the first is the competitive forces as the shifts in demand and supply, barriers of entry etc. The other reviews productivity and efficiency issues from the resource allocation point of view. Although both viewpoints are connected to the quality and pricing issues, pricing and designer selection systems like the Qualification Based System (QBS), even though current, are excluded from the topics and the focus is on the two main viewpoints.

2.1 Deregulation and Competitive Forces

In the long run in stable conditions the demand (D) and supply (S) forces are in equilibrium at quantity Q* and price level P* [11]. In a pure free manufacturing market the forces caused by regulation and such are assumed stable and hence won't distort the equilibrium. In A/E service sector the product is a complicated process. The supply providers (S), i.e. A/E consultants, feel that the present demand leads to an underperforming product and the demand (D). The customers feel that the supplied service over- or underperforms and too seldom is a "perfect match".

Equilibrium for such forces should be described more like a grey area than a single point. The objective is to get a better understanding of these forces.

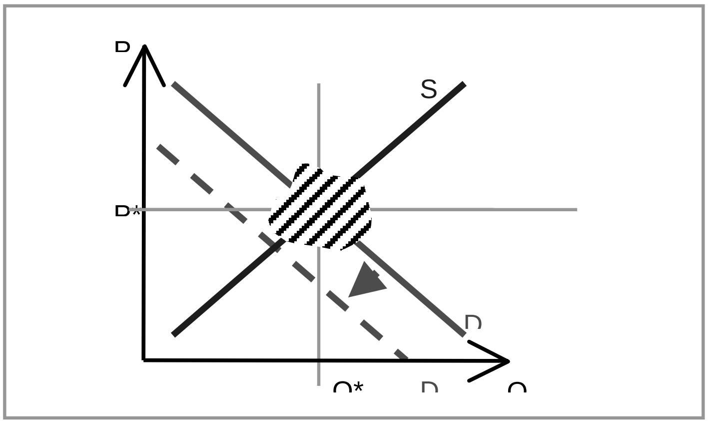


Figure 1: the shifts in demand and supply in A/E industry

2.2 Productivity and Efficiency

The other main viewpoint is the productivity of the A/E industry. It is divided to three subtitles: service sector viewpoint, ICT, and measurement. The first object is to distinguish the impact of the ICT from the impact of competitive forces focusing mainly on the impact of 2D CAD. The second viewpoint deals with the service management theory, external and internal efficiency, recourse allocation etc. The third viewpoint deals with its measuring problem of productivity. It is questionable whether the object defined as productivity in many even official statistics actually measures A/E consulting efficiency. The object is to understand the efficiency factors in the defined context i.e. competitive market.

3. Methodology

Because the impact of changing competitive forces is not purely statistical, comparable cases are evaluated. The methods that are used for measuring A/E consulting productivity have been criticized. In this article an additional comparable analysis utilizing recent service management concepts is applied. It also involves planning resource allocation concepts that are evaluated further in the research project “Developing the design system for CM contracts” in HUT [9]. The methodology can be divided into three categories, statistical analysis, comparable case analysis (peer groups) and comparable method analysis (theories).

3.1 Statistical Analysis

The statistical data is provided by ATL, the Association of Finnish Architects' Offices; SKOL, The Finnish Association of Consulting; Statistics Finland; FIDIC, professional journals and Swedish Government. Some international figures provide comparable supportive information.

The total net sales of architectural services in Finland declined 57 %, from 252 M€ to 109 M€ in five years since 1990 and wasn't fully recovered until year 2000 [1]. The total output in cubic meters excluding agricultural construction at the same time fell 58 % from 50 million m3 to 21 million m3 in only four years since 1991. Respectively the total national net sales of SKOL members in structural services declined 63 %, from 90 M€ to 33 M€, in HVAC 62 %, from 47 M€ to 18 M€, and in electrical engineering 57 %, from 37 M€ to 16 M€, in five years since 1990. They reached the level of year 1989 between 2000 and 2002 depending on the sector. The year 1991 remained as a record (peak) year [12], [14]. The GDP per inhabitant at current prices was in 1995 18650 € and in 2003 27 496 € (increasing from 1995 to 2003 47 %). According to the national Statistic Finland the present productivity figures of the service sector are negative. Real estate maintenance and business services it was - 7,8 % and in construction sector -0,8 % [8]. However, the productivity definition in previous figures may be misleading.

Table 1: The national net sales of architectural services vs. cubic meters produced

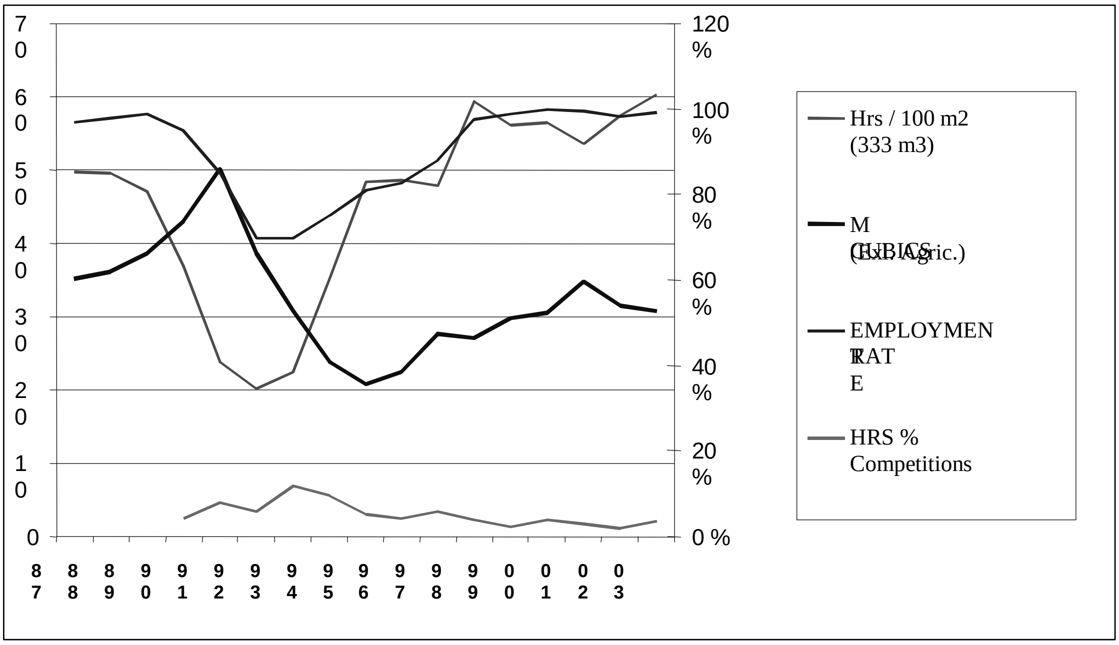
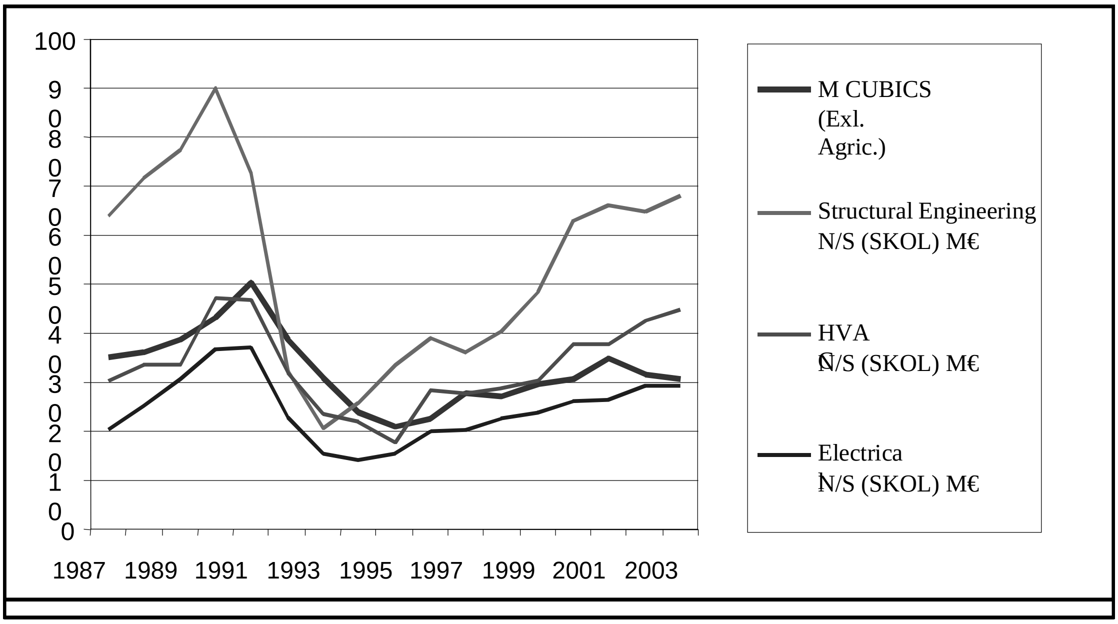


Table 2: The national net sales of engineering in construction vs. cubic meters produced



3.2 Architectural and Engineering Services in US

In the US market there are approximately 17 000 firms providing architectural services. They all together make annual revenue of $ 20 billion (total). Less than 100 of these firms have annual revenue over $ 100 million. A median firm has 10 employees and an annual revenue of 1 $ million. The US engineering service industry has approximately 45 000 firms with making all together annual revenue of $ 90 billion (total). The 50 largest of these firms cover 35 % of the total annual revenue and about 100 of these firms have annual revenue over $ 100 million. Nearly 50 % of the firms have less than 5 employees.

3.3 Comparable Case Analysis (Peer Groups)

3.3.1 Swedish Taxi Licence Deregulation

The Swedish taxi licence and price control system was liberated in june1990 [3]: After the deregulation the prices went up roughly 35 % in a year. Since that the price level has increased less dramatically but clearly over the index (by 40 % until year 2004). The increase has also beaten the production cost growth. The report found some potential explanations e.g. a price shock directly due to the deregulation or a quality improvement as a driver. However, the most preferable conclusion is that the product taxi-trip changed. Customers accept a higher price for being sure to get the cab immediately. The queuing time had been the main source for complaints before the deregulation.

3.3.2 TV licence fee deregulation / Case MTV3

MTV3's total licence fees of about 40 M€ were halved in year 2001 and since that gradually removed [2]. MTV3 controls about 80 % of the Finnish TV advertising market. TV Nelonen's, the main competitor's, licence fees were cut in the same proportion. MTV3's broadcasting generated in 2003 178 M€ net sales (year 2000 178 M€) and an operating profit 6 M€ (in 2000 1,5 M€ and in 2004 over 10 M€). Because the costs fell dramatically, the advertisers could have demanded price cuts. Actually MTV3 managed to maintain and even slightly to raise its price level. Since 1997 Nelonen's pricing had been aggressive. After the licence cut it saw the situation as an opportunity and the whole sector's price level raised.

3.3.3 Generic Substitution

According to data based on the Prescription Register maintained by the Social Insurance Institution of Finland (KELA) the generic substitution [13] and drug price reductions, brought on by price competition, generated 39.8 M€ savings in Finland in the first six months of the new procedure. The patients' share of the savings was 17.5 M€ and 22.2 M€ million was saved in drug reimbursement payments. The amount saved approximated to 5% of the total cost of all reimbursed medicines

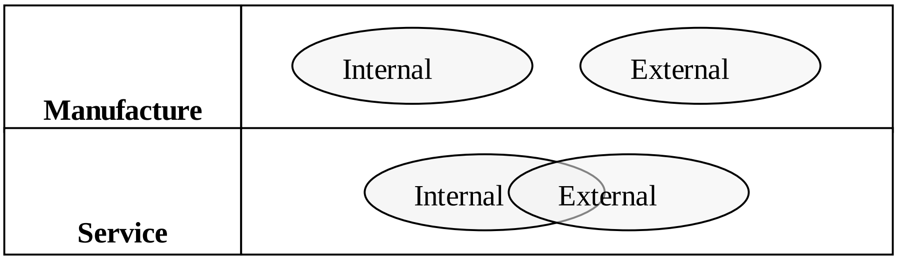
3.3.4 The Belgian Architects' Association's Fee Scale

According to the Commission's preliminary investigation [4] the fixed fee scale has been frequently used in architect's contracts. In 2000 the turnover of this type of architectural and engineering services amounted to € 4.4 billion which corresponds 15% of the total turnover achieved in the Belgian construction sector. The commission sees the fee system as a serious barrier of entry.

3.4 External and Internal Productivity; Service Management

Efficiency is a complicated phenomenon with at least two dimensions, internal and external efficiency. Internal efficiency is related to firm's productivity of labour and capital. External is defined as a way the customer perceives the output (i.e. in the mind of customers). In manufacturing the interrelationship between internal and external is less important. Customer simply receives the output. But in service the customer is involved in the production process (i.e. process consumption) and perceives not only the output but parts of the process itself. In a way customer might be seen as a co-producer [5].

Figure 2: the service management theory: internal and external efficiency



The net sales figures are collected by the Statistics Finland. However, the distinctions between A/E service sectors (e.g. the distinction between architectural end interior designing, landscaping may vary). On the other hand, the information of SKOL and ATL, even though quite accurate, covers only the members. The total cubic meters constructed are the national total figures collected by Statistics Finland. The coefficients are calculated as a ratio of the given net sales and the total cubic meters. Thus, despite their accuracy may vary, the correlations of the ratios are valid. The calculations are based on yearly basis working hours and current values (inflation and NPV excluded).

4. Results

There are two main findings. The outcome of the competitive deregulation has barely been what expected even though the quality deterioration seems indirect; that is, in the long run the society is the loser and the winners are not the end users. The service providers' (A/E consultants') productivity is generally expected to improve as a consequence of the "lean consulting". The other finding implies that the national data on productivity is more contradictory. The evaluated time period from the early 90´s should indicate the efficiency improvement brought by the 2D CAD. However, depending on the measurement unit, it seems minor than expected.

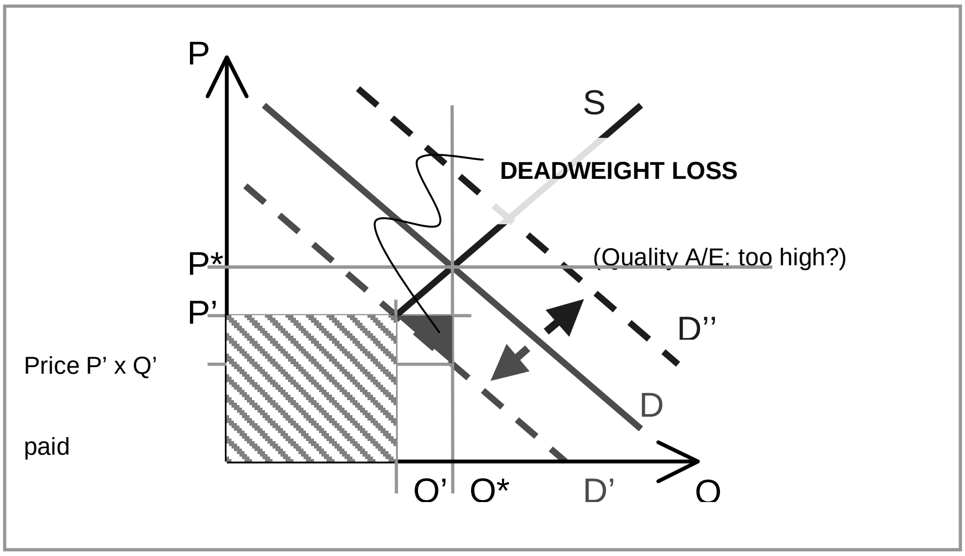
Competition Commissioner Mario Monti said: "Fixed or recommended fee scales can harm both consumers and professionals. It is doubtful whether fixed fee scales really contribute a high level of quality. On the contrary, they can prevent consumers from finding the best match to their needs (additional value). The professionals have no incentive for innovation and cost efficiency." According to Mr. Monti the fixed fee system protects less efficient competitors and reduces incentives to improve quality. The fees should reflect the architect's skills, efficiency and costs and only in some cases fame and should not depend only on the value of the output.

The Competition Authorities see the fixed fee system as a barrier of entry and use deregulation as a supply-side tool. However, the A/E service market is quite demand driven. It is hard to distinguish whether the driver is the service provider's desire to sell more or the customer's willingness to buy less (minimum level required). Structural engineers and architects seem sometimes to be willing to produce even a higher quality than the customer is willing to buy; quality in this context meaning the designer's will to raise the quality of the end product.

Architects are also eagerly participating in architectural competitions and perhaps willing to invest to the town scenery more than the investor would. The estimated amount of free work varies from 2 to 5 % and results as a consumer surplus for the society and dead weight loss for architects. Similar “red cross” attitude can be identified also in structural engineering. Nevertheless, the recent crashing roof incidents, unfortunately also in Finland, occurred in Design & Build projects; in which the customer itself defined the level of the service integration.

If the demand and supply equilibrium is distorted in such a way, the demand curve shifts left. In the chart it is illustrated with red triangle area, (deadweight loss). Its value could be theoretically calculated (Q*P/2) resulting either as consumer surplus or deadweight loss for the society. It resembles the monopoly evaluation chart dilemma applied in managerial economics [10]. The deregulation tools that the authorities have used have shifted the demand curve left distorting the equilibrium. In case the distortion is simultaneous with a declining demand (recession) as it was when FCA acted in the early 90’s, it may strengthen the impact. If so, the timing of FCA was not successful. Distortion may also indicate that the planning resources are not efficiently allocated. When they are allocated efficiently also the equilibrium is achieved easier. Another possible outcome is that the number of acceptable (either by the customer or the designer) solutions or options diminishes. An example: architectural trends becoming also “lean”; that is, allowing less freedom or flexibility within one concept. In manufacturing business an example of this under the name of globalization would be the diminishing selection of ice cream types (case Unilever).

Figure 3: the demand and supply chart: deadweight loss for society



4.1 Economies of Scale

As globally, also in the US architectural industry is highly fragmented. Because most costs are fixed, profitability depends on the constant inflow of the work. It is likely that the architectural firms are small because there are few economies of scale i.e. the cost of architectural design has a little to do with the size of the firm. The US engineering market is also highly fragmented. The profitability depends highly on the ability to accurately predict the costs of the project. Small profitable firms have often an expertise in a particular field and are often hired as consultants on larger projects. Large firms design and manage larger projects. In small markets (like Finland) customers minimize risks by selecting the same architect, whose projects were in previous projects successfully sold out (personification).

The evidence supports the hypothesis that A/E consulting is traditionally more fragmented. U.S market is a mature market, but still in architecture industry mergers and acquisitions are not common. On the other hand, partnering is common in many forms among A/E business providers. Process engineering projects are of more global character and the project size can get extremely large. No evidence supports the argument that achieving economies of scale in A/E consulting would increase profitability. Process and forest engineering businesses have reached economies of scale due to their different market structures.

4.2 Analysing Productivity

The given data on ICT's efficiency is controversial. The hourly-based ratio i.e. how much A/E has produced compared to the national total construction figures does not indicate any clear efficiency improvement when excluding the recession period. The data is preliminary and further analysis on the data is under procedure. For instance at the final rush stage of the construction process architects are increasingly printing A4's, sketching details on the A4's, and faxing them to the site. The question is: why architects prefer this in a hurry? One explanation might be that because even a single CAD dot has to be defined in exact units, sometimes the imprecise pencil is a quicker tool. In addition, the statistical productivity figures applied from the manufacturing industry don't measure the productivity of the service industry. The productivity (Statistics Finland) is defined as the ratio between the net sales and the number working hours (L). Further in A/E consulting the net sales are defined as the average hourly-based charge (P) times the number of hours (L). Hence the formula P*L/L is a coefficient and simply tells the average hourly-based charge (P). These negative service productivity figures tell only that the average hourly-based charges have declined and furthermore the A/E consulting cost for the customer has declined in the same proportion.

4.3 The Service Management Theory

The service management approach introduced the concepts of internal and external efficiency. Service managers believe that developing services with 100 % quality is impossible. Customers are not prepared to pay for improved service quality. When applying the business logic of traditional manufacturing to service business the profitability may start declining even though productivity as internal efficiency is increasing. This may be the case when applying traditional Design/Bid/Build methods i.e. the customer not interested in the high productivity service. According to the theory an equilibrium in which the profitability is peaking may be found [6]. In A/E service business it requires better planning resource allocation. An example of such is HUT's research project "Developing the design system for CM contracts" [9]. including e.g. a retrospective study on A/E designing processes' integration to procurement processes. The preliminary result implies e.g. that the planning resources of the Special Product Contractors (SPC) are not efficiently utilized. The project will be published in the beginning of year 2006.

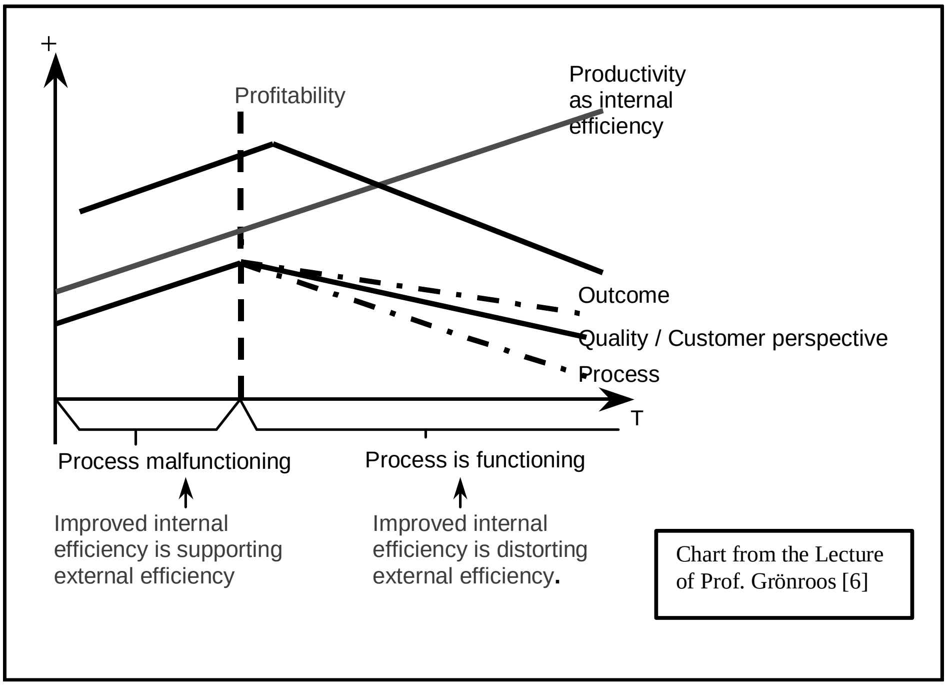


Figure 4: the service business the profitability vs. internal and external efficiency

5. Conclusion

According to Mr Monti the fee would reflect the skills and costs of the consultant, which involves an idea of the price (fee) as the main driver in competition. Undoubtedly no competition no efficiency – doesn't benefit the society. The evidence shows that after a deregulation a price level can get stuck on a surprising level and shift the demand to an unexpected direction. However, the evidence is preliminary because the processes are still going on. In addition, the overwhelmed lean consulting expectations on ICT have probably been also one factor in the demand shift.

This article is not arguing that a price war automatically deteriorates quality. However, the timing and methods of deregulation (removing entry barriers) might have been more targeted; that is, "tailored allocation of the competitive forces". A valid question is how to increase competition and to shift the demand curve to the right? It is not likely that legislative tools are successful. Legislation undoubtedly has a strong influence on construction economics. It is also argued that the actual designing work has become more efficient due to ICT whereas planning resources are wasted in the increasing number of required statements, accounts of energy, health and fire regulation etc. Another argument is that under the name of healthier air new regulations requiring new equipment are rammed easier through. In general the influence of the legislative and regulatory framework is a subject for further research.

Many of these tools have the same limitations as fiscal tools in economics. They are of political character. A Keynesian increase in government spending hardly improves A/E quality and efficiency in the long run. A/E market can react in two ways: either adapting to the free competition or reacting to the market failures. The more the A/E consulting adapts to the demand-side, the more the customers “pull”, and the closer it gets to perfect competition. As the term perfect market is something of a misnomer, in order to minimize the market inefficiencies, the town plan regulations and such should be brought under the deregulation also. The idea doesn’t fit too well to the “mixed” type Nordic economy. Japan’s construction industry provides an opposite example: firms competing on the basis of technology in contrast to the price-based competition [11].

If A/E consulting chooses to develop tools for shifting the equilibrium point, such tools could involve revising licensing and/or quality measurement procedures, but a strict licence policy leads to an opposite direction than the deregulation. Nevertheless, European Commission has increased licence requirements. In addition, in a supply-driven economy R&D is seen as a driver. The question is how to create a win-win situation for the customers and the service providers? Research projects and designer selection methods e.g. Value Pricing, PIPS, and different qualifications for buying, selling and producing A/E consulting services and allocating planning resources efficiently will become the key success factors of the future construction business.

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Section IV

Modelling and understanding added value

An Analysis of Value Determination in the Building and Construction Industry

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Abstract

This paper discusses the concept and definition of 'value' that is crucial for a research into *value quantification in the Dutch building- and construction (BC) industry*. The goal of this Ph.D. research is to find some scientifically sound methods for quantification of value for the Dutch BC industry. This is necessary because value remains implicit in the Dutch BC industry, being the reason that decisions based on the value-price ratio cannot be made. Definitions are described from different perspectives. Subsequently these aspects of value are evaluated. As a result, *the value of a BC project is defined as the amount in which all persons involved are influenced in their well-being by the project*. How the concept of value is used within the context of this paper is illustrated by placing the concept of value in a value model. The definition and model will be used in the forthcoming stages of this research project, in which public clients, knowledge institutes, contractors and developers will participate.

Keywords: Value, value definition, value determination, value quantification, Value-Price-Cost model.

1. Introduction

It is argued that the use of a Value-Price-Cost (VPC) model is essential for improving the performance and effectiveness of the Building and Construction industry (BC) [1]. The last two factors in this model, namely the price and cost, have been the subject of numerous investigations while the first factor, i.e. value, remains to be explicitly defined and hence requires further investigation.

For the VPC model to work, the value for several construction objects has to be established, thus a value-determination or value-taxation system is needed. This proves to be difficult, because the different project stakeholders tend to have different (subjective or partial) opinions about the project value. Also the value can alter due to changed insights and circumstances, pointing to the necessity of formulating a sound value-assessment methodology, acceptable by all project stakeholders.

Value determination is a subjective process. When more than one person or interest group are involved, which is often the case in the BC industry, selection of the alternative with '*best value* *for money'* becomes difficult. Decision makers need an acceptable (realistic and fair) method for determining the total value of an alternative solution. This implies that they need to combine partial value judgments into a total value judgment. The most common methods to do so are (societal) Cost-Benefit Analysis (CBA) and Multi-Criteria Evaluation (MCE). Most impact-evaluation methods can be used as a part of one of these two analysis methods [2, 3, 4].

The disadvantage of CBA is that some costs or benefits cannot (easily) be expressed in monetary terms. On the other hand these types of effects can be taken into account with the MCE. The problem of the MCE is that weighing of effects can be arbitrary.

In this context, a deeper understanding of the concept of 'value' is needed. In section 2, existing definitions of value are described. These definitions of value are evaluated and, as a result, a general definition of value is formulated, applicable to the BC industry. In section 3 it is made clear how the concept of value determination is used in this article and what is meant by it. Section 4 states the planned research and section 5 concludes this paper.

2. Definition of value

Decision-making processes in the BC industry, often involves using the concept of value. Although roughly pointing at the same thing, several meanings can be attached to the concept of value. A definition of value is needed for a meaningful communicating of the subject of quantification of value.

Section 2.1 presents an inventory of different views on 'value'. These are compared in section 2.2. Subsequently, a definition suitable for the research is formulated in section 2.3.

2.1 Different views on value

There are numerous views to describe the notion of value [URL 1, URL 2, URL 3]. Several definitions of value have been found in literature. Next sub-sections discuss the most important and relevant definitions value for the BC industry.

2.1.1 Value engineering definition

According to Kelly [5] value is a measure expressed in currency, effort or exchange or on a comparative scale which reflects the desire to obtain or retain an item, service or ideal. Most sources in the literature represent the relationship of value to function and cost by the following expression:

$$Value = \frac{Function}{Cost}$$

‘Function’ is a characteristic activity or action for which a thing is specifically fitted or used or for which something exists. Therefore something can be termed ‘functional’ when it is designed primarily in accordance with the requirements of use rather than primarily in accordance with fashion, taste or even rules or regulations. Value engineers distinguish between a basic function and a secondary function. A basic function is defined as the performance characteristics that must be attained by the technical solution chosen. Secondary functions are the performance characteristics of the technical solution chosen other than the required basic function.

According to this definition, value is a ratio, of which the dimension is dependent on the unit of function. The ratio resembles efficiency or productivity.

The outcome of decisions using this definition depends on the way functionality is measured.

2.1.2 Definition used in economics

Several definitions of value can be founding the economic literature. A general definition of value is “the amount (of money or goods or services) that is considered to be a fair equivalent for something else”. This is also called ’willingness to pay‘. For different customers, the willingness to pay differs. They value the product differently. One customer may derive more utility from a product (or has more to spend) than another.

In neoclassical economics the ‘willingness to pay’ for different people is combined into the demand curve. The ‘minimum supply price’ for several suppliers is combined into the supply curve. The neoclassical theory states that in an open and competitive market, equilibrium will be reached and the society’s net valuation is maximized (Figure 1) [6].

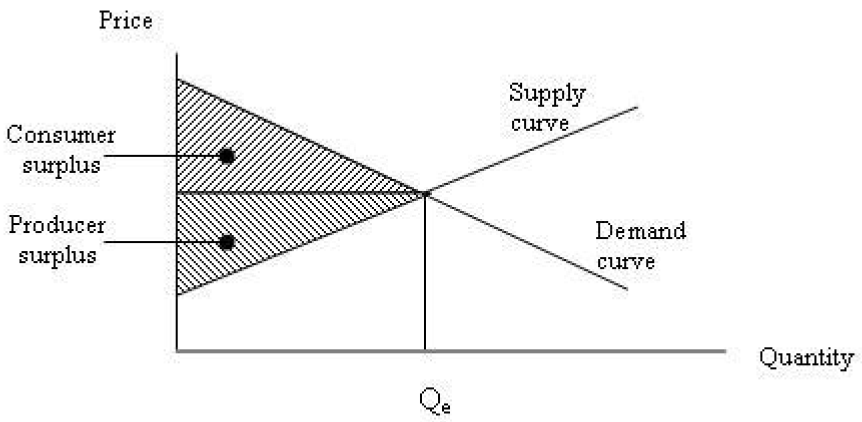

Figure 1: Market equilibrium & related principles

To neoclassical economics, the value of an object or service is often seen as nothing but the price it would bring in an open and competitive market. This equilibrium value is referred to as market value. Consumers who would be willing to pay more than the market value experience a benefit. This difference in value is called the ‘consumer surplus’. Producers who would be willing to sell for less than the market value also experience a benefit. This difference in value is called the 'producer surplus'. The total surplus, the sum of consumer surplus and producer surplus, is called the net valuation in a market. As stated earlier, at equilibrium the society's net valuation is maximized.

2.1.3 Value-Price-Cost model definition

As a framework for analysing transactions in the BC industry, De Ridder [1] introduced the Value-Price-Cost model (Figure 2).

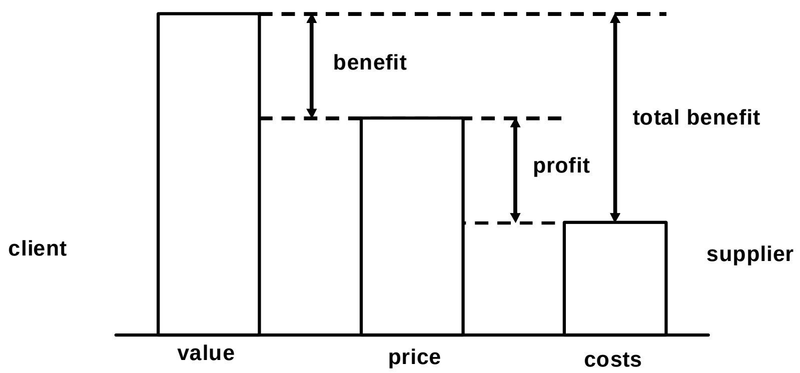

Figure 2: Value-Price-Cost model

The parameters in this model can be compared to the principles of neoclassical economics. Value relates to the willingness to pay for a certain object. In theory, the cost is the minimum amount a producer is willing to accept. The price lies somewhere in between value and cost, dividing the total benefit into a consumer surplus and a producer surplus.

2.1.4 Cost-Benefit Analysis definition

In an integral or societal Cost-Benefit Analysis (CBA), value consists of all the plusses (cash-flows and other intangible benefits) of a project. The value is compared with all the minuses (the costs and disadvantages) of the project[1]. As with the previous two definitions, the difference is the net value or total benefit.

A frequent problem with CBA is that typically the costs are tangible, hard and financial, while the benefits are hard and tangible, but also soft and intangible. Caution should be taken here against people who claim that "if you can't measure it, then it does not exist or it has no value". Especially in more strategic investments, frequently the intangible benefits clearly outweigh the financial benefits [URL 4].

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1 An example of a CBA with an elaborated quantification of value can be found at http://www.partneringmodel.nl

The starting-point of a societal CBA is that the ‘go/no go’ decision is based on the effects the project has on the well-being of all citizens. This starting-point is known as welfarism [3].

Welfarism is based on the premise that actions, policies and/or rules should be evaluated on the basis of their consequences. Welfarism is the view that the morally significant consequences have impacts on human welfare. There are many different understandings of human welfare, but the term ‘welfarism’ is usually associated with the economic conception of welfare. Economists usually think of individual welfare in terms of utility functions. Social welfare can be conceived as an aggregation of individual utilities. Welfarism can be contrasted to other consequentialist theories, such as utilitarianism.

Welfarist views have been especially influential in the law and economics movement. Shavell and Kaplow have argued in their influential book “Fairness versus Welfare” that welfare should be the exclusive criteria by which legal analysts evaluate legal policy choices [URL 5].

Van der Heijden [2] presents three methods for expressing the effects of projects. If the advantages and disadvantages of a project can be measured in physical units, valuation can be based on existing market prices. Prerequisite to this is a well functioning price mechanism. Is this prerequisite lacking then the so-called shadow- or calculation prices can be used. For non-priced effects, many approximation methods can be found in the literature. Non-priced effects are effects corresponding to products and/or services, for which an (economic) market doesn’t exist, such as clean air.

2.1.5 The ethical definition

The values that a group or person holds are usually categorised into ethical values and ideological values.

Ethical values may be thought of as those values, which serve to distinguish between good and bad, right and wrong, and moral and immoral. At a societal level, these values frequently form a basis for what is permitted and what is prohibited.

Ideological values deal with the broader or more abstract areas of politics, religion, economics, and social mores. In theory, the broader ideological values should derive logically, as natural consequences from the particulars of fundamental ethical values and their priorities. But although ideally a value system ought to be consistent, quite often this is not the case [URL 6].

2.1.6 The financial definition

Investment decisions are often based on the difference between expected costs and expected revenues. To compare future cash flows, the Net Present Value (NPV) is calculated. Sometimes aspects like quality (-deterioration) and risks are included in these calculations. If the calculated value is positive, the ‘go’ decision is likely. If the value is negative, the ‘no go’ decision is very likely. Typically the alternative with the highest value is selected. Often the result of decision making using this financial definition of value depends on assumptions about parameters such as interest.

2.2 Evaluation of definitions

Based on this (non-exhaustive) literature research, already some conclusions can be drawn. All definitions except the ethical definition compare some level of performance, functionality, utility, benefit or quality (-perception) with the associated level of price or cost. Three categories can be distinguished: value as a ratio (I), value as a surplus (II), or value as an absolute quantity[2] (III), as illustrated in Figure 3.

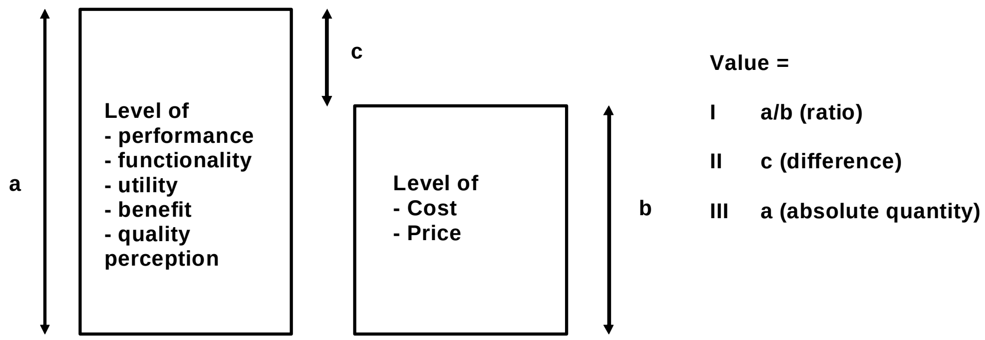

Figure 3: Three categories of value definitions

The value engineering definition belongs to the first category, the financial definition to the second. The economic and the Value-Price-Cost model definitions belong to the third category. The Cost-Benefit Analysis definition is used in both the second and third category.

2.3 Definition of 'value' for this research

Methods for determining the cost of BC objects and in a lesser degree the price are well-known, well-researched and sometimes quite straightforward. But the determination of the level of performance, functionality, utility, benefit or quality (-perception) is much less straightforward and often subject to discussion and hence the subject of this investigation. The focus is on the

[2] In the mathematical sense "absolute" means bigger than zero. But value can also be negative, when a project has a negative impact on a stakeholder. In the context of this article "absolute quantity" should be read as "some level of performance, functionality, utility, benefit or quality (-perception)".

elaboration of the level of performance, functionality, utility, benefit or quality (-perception). Therefore ‘value’ will be defined as some absolute quantity (category III).

Also the welfarism viewpoint is adopted. This viewpoint originates from the cost-benefit analysis and states that a person or group becomes a stakeholder as soon as they are affected in their well-being to some extent. This leads to the following definition of value:

> *The value of a BC project is the amount in which all persons involved are influenced in their well-being as a consequence of the project.*

This definition is still quite broad and makes quantification of value difficult, because it is hard to establish measurable relations between (features of) constructions and the well-being of people. How to measure this “effect in well-being” still needs to be translated into practical guidelines and assumptions. This requires introducing simplifications.

The definition contains the notions of subjectivity and negotiation. In this paper, value is a part of a decision-making process. It puts the focus from the build object, to the psychology of those who experience the effects of the build objects.

3. Value model

Based on the definition of value, a model for value determination is composed, incorporating elements from the Multi-Criteria Evaluation method, integrated decision-making and stakeholder analysis. The value determination model is incorporated into the Value-Price-Cost model, shown in Figure 4.

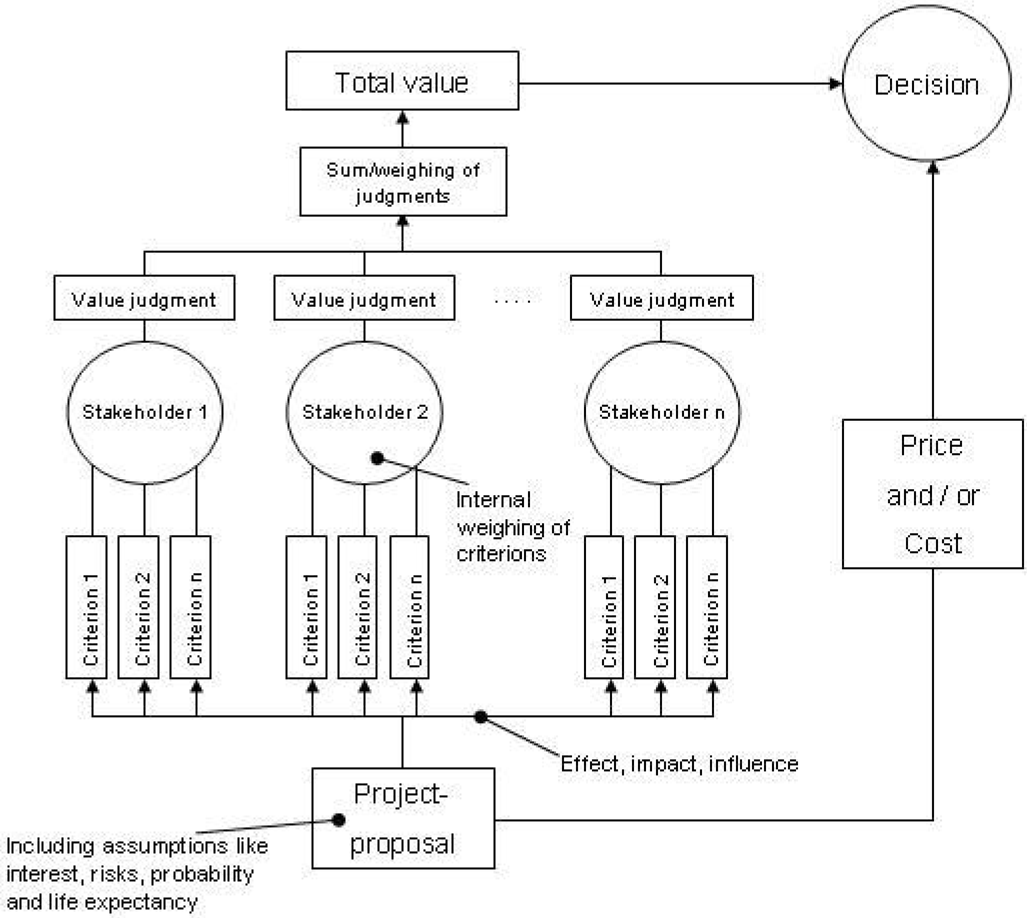

Figure 4: A model for value determination incorporated in the Value-Price-Cost model

In the model, the value judgments of the people or groups that are affected in their well-being by a project proposal (the stakeholders) are added up to determine the total value of a project. If the value judgments are quantitative and comparable, they can simply be summed up. This is the case when the value judgments are expressed in monetary terms and the judgments have equal weight. If the value judgements are qualitative or are not comparable, they have to be weighed in order to determine the total value.

The value judgment of a stakeholder is determined by the effect of the proposed project on his or her well-being. This has often several dimensions; a project proposal can have several impacts on several aspects of the well-being. The stakeholder implicitly weighs these influences and reaches a value judgment. This weighing is influenced by personal preference, perception, pre-disposition and the available background information.

4. Goals and planned follow-up

The formulated definition of value and the model for value quantification will be used in this Ph.D. research into quantification of value. The preliminary work plan contains several elements. First, several parties from the BC industry will be involved. Public clients, knowledge institutes, contractors and developers will be interviewed about how they quantify value. This will be done for several construction types. An inventory of their methods and needs will be made. The methods and their area of application will be structured into a value quantification system. The developed value quantification system will be tested and validated, in some real life projects or as a hind-cast simulation. This will refine the value quantification system.

5. Conclusions

In this article, several definitions of value have been compared. Three categories of definitions were encountered. This proved to be very useful, because it becomes clear that using definitions from different categories could result in fundamental communication- and interpretation problems.

The value of a BC project is defined as *the amount in which all persons involved are influenced in their well-being as a consequence of the project.* The definition contains the notions of subjectivity and negotiation. In this paper, value is a part of a decision-making process. It puts the focus from the build object, to the psychology of those who experience the effects of the build objects.

In the value quantification model, value is treated as a multi-dimensional property of a project proposal. In the planned Ph.D. research it remains to be seen whether clients in the BC industry are able to define their “willingness to pay” without the knowledge of other projects.

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Advancing Life Cycle Economics in the Nordic Countries

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Abstract

Advancing construction and facilities management requires the ability to estimate and evaluate the economic consequences of decisions in a lifetime perspective. A survey of state-of-the-art on life cycle economics in the Nordic countries showed that, despite a number of similarities, no strong convergence of i.a. methodologies has occurred. Thus, a Nordic network of researchers, practitioners and authorities was established along with national networks. Within these networks, similarities and differences in approaches were explored. Three conclusions were reached. First, it was suggested that the configuration of the roles as client, owner and user is indicative of a client's interest in life cycle economics. Second, a proposal for a common Nordic cost classification was put forward. Third, it was argued that there is a strong need to develop tools and methodologies to depict the cost/value ratio appropriately.

Keywords: Clients, benchmarking, cost classification, value, life cycle cost

1. Introduction

Facilities management is increasingly being recognised as an important strategy for improving building performance and optimising the economic return on investments. Although differences exist with respect to purpose, scope and priority, facilities management has now become a mature field with its own textbooks etc. [1].

An important element in facilities management is the ability to estimate and evaluate the economic consequences of decisions in a lifetime perspective. The potential for a significant reduction in facilities investment costs is demonstrated in e.g. post offices in Japan [2], and it is shown that life cycle operations, maintenance and recapitalisation costs over e.g. a 50-year life cycle represent the greater part of life cycle costs [3]. Nevertheless, the uptake of life cycle economics has been rather limited. The reluctant uptake has been explained by several factors. Among those are the fact that management focus is typically directed at the initial construction costs when making decisions about buildings [3], various types and quality of data [4], and a host of practical, behavioural and methodological difficulties [5].

Recently, international convergence on methodology and cost classification has been sought by ISO (International Organisation for Standardisation). In relation to the ISO 15686 series on service life planning, Part 5 addresses whole life costing [6]. In parallel, convergence has also been sought on a Nordic level. Although the Nordic countries more or less share the same visions and methodologies regarding life cycle costing, different cost classifications and tools are in use [7]. Thus, the Norwegian government's building and real estate agency Statsbygg together with the Danish Building Development Council, a Danish think tank, initiated a Nordic project in order to establish Nordic networks for knowledge exchange and to develop a common Nordic cost classification. The purpose of this paper is to report the findings of this project, which is further described in [8].

2. Methodology

The research methodology included data from three main sources:

- A survey of state-of-the-art through visits and seminars in each of the Nordic countries during 1999-2001.

- An extensive literature review based on searches in Nordic databases.

- A dialogue approach based on six thematic Nordic workshops and a number of national network meetings during 2002-2004.

3. Typology of clients

The client's role is very important in relation to development, implementation and use of life cycle costing (LCC). Without an active and systematic demand for LCC from the client, the possibilities of LCC related considerations to make a break-through in the building sector are very limited. The client must possess a wide competence to handle planning, construction and operation of buildings. This puts focus on the client's handling of the relations to all the stakeholders, i.e. the owner, the customers, the building sector and society (see Figure 1). The client's handling of these four relationships requires different capabilities [9]:

- *Relation to the owner:* The client must be able to estimate whether investments in a building project fulfil the estimates and demands for profitability and economic conditions that apply to the actual business ideas of the owner. The estimates will of course be different for e.g. social housing, governmental buildings or commercial facilities.
- *Relation to the customers:* A prerequisite for the client's work is knowledge regarding the wishes, needs and demands of the customer as well as the will and ability of the customer to pay. For both unknown and known customers, the client will be the one to crystallise and specify the requirements to the building. With unknown customers it

requires knowledge of the market, the supply situation and competition, the customers' preferences etc. With known customers – e.g. inside own organisation – the ability to negotiate will often be needed to balance requirements versus costs and other consequences, etc.

§ *Relation to society:* The client must have knowledge of society's requirements to both the building and to the client's responsibility, as they are stipulated in laws, regulations, etc. The relation to society also includes handling public opinion, architecture and the environment in the broadest sense.

§ *Relation to the building sector:* The client's purchase of services like design and construction from the building sector assumes an ability to formulate relevant requirements and to organise and manage the process including control and follow-up. The handling of the relations to the building sector put great demands on the legal competence as well as the client's ability to handle risk.

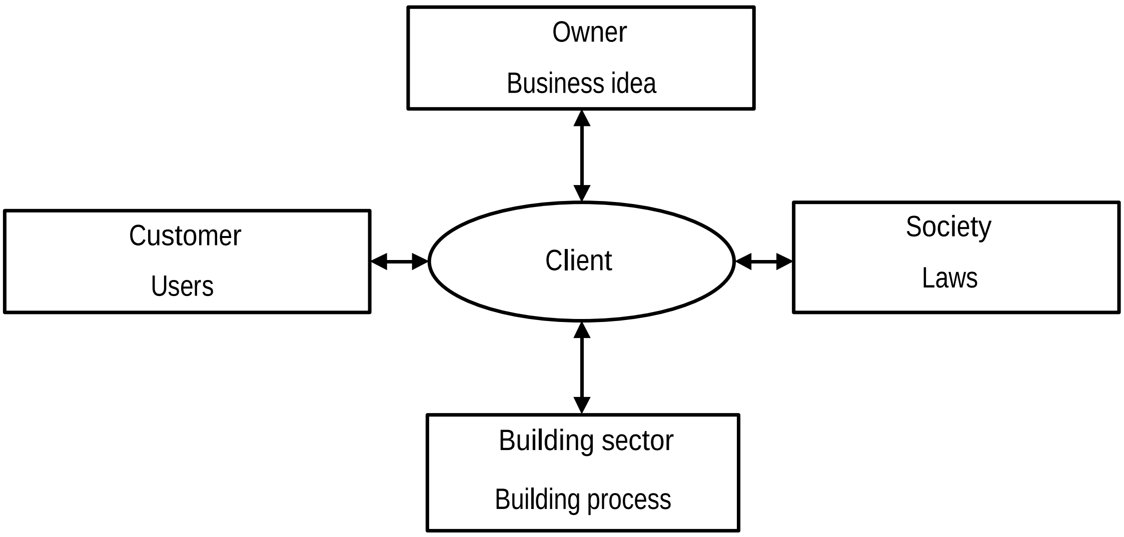

Figure 1: The relations of the client to the various stakeholders. Based on [9].

The Nordic project identified four trends that are changing the role of the client in the Nordic countries. Firstly, public clients increasingly have to operate on market conditions. Secondly, the ability of the client to handle demands and partners in the building sector that are often contradictory is becoming more critical in order to achieve better value. Thirdly, the corresponding national property indices based on the Investment Property Databank (IPD) have made it easier to compare the profitability of building investments. Fourthly, the behaviour of the users is increasingly being recognised as decisive for the operation of a facility.

As stated by Bordass who discussed the costs and value of greener buildings and how they are perceived and assessed [10], a client's adopting of life cycle costing or not in his practice will to a large extent depend on his incentives to pursue lifetime considerations. The incentives will in turn be determined by how the role as client, owner and user is configured. Based on the Nordic project three different configurations were found to be possible:

- § *Configuration 1 – client only*: In this configuration, the client acts as a client only, and he does not occupy the role of neither owner nor user. Some clients may pursue lifetime considerations due to ethical concerns, but his economic incentive lies solely with fulfilling the task at hand – to deliver a building. Since the market pressure and the public regulation for lifetime considerations have notoriously been weak, he is rather unlikely to make lifetime considerations. Thus, this type of client was labelled the Hit-and-Run Client.
- § *Configuration 2 – client-owner*: In this configuration, the client will act as both a client and owner (or facility manager), but he will not be the end user of the facility. As Bejrum et al. [11] convincingly argued, the profitability of a facility lies in the right maintenance strategy. Thus, this type of client-owner could pursue lifetime considerations since he might have economic incentives to optimise the performance of the building in question. This type of client was labelled the Landlord Client.
- § *Configuration 3 – client-owner-user*: In this configuration, the client will act not only as a client, but also as both owner and user of the facility. This type of client would in principle have strong economic incentives to include lifetime considerations in his decisions, since he is building for his own use and has to pay all the costs. Therefore, he is likely to be interested in optimising the performance of the building in the long term. Thus, this type of client was labelled the Integrative Client.

4. Nordic cost classification

For clients who wish to include lifetime considerations in their decision-making it is a prerequisite that costs are systematically and consistently collected, classified and validated. The Nordic countries have many years of experience in collecting various key performance indicators. However, classification of cost and the scope of each system have been different within each country. Thus, it was a major objective of the Nordic project to put forward a proposal for a common Nordic classification of costs. Obviously, the ongoing work on ISO 15686-5 [6] was closely followed. But ISO 15686-5 was discarded, because the terminology was perceived as inconsistent, the standard contained a mix of normative and informative elements, and the cost classification was too far away from practical experiences in the Nordic countries. Instead four other basic requirements were set up and pursued.

First, a distinction must be made between (at least) three main groupings of costs associated with the acquisition of the building, the building related services, and the non-building related services (services related to the core business taking place in the building).

Second, the three main groupings must be broken down into main services. To be able to maintain an overview, the number of main services should not exceed 10. Each of these main services could be broken down in more details if needed by the individual user, but it was suggested that splitting into sub-categories should in principle follow the hierarchical structure shown below:

- § One-figure level indicates a *main service* e.g.: 6. CONSUMPTION
- § Two-figure level indicates a *specific service* e.g.: 63. Waste handling
- § Three-figure level indicates an *activity* e.g.: 63.1 Internal transport
63.2 Compression
- § Four-figure level indicates a *resource* e.g.: 63.1.1 Equipment
63.1.2 Salary

Third, a cost classification should be based on existing systems and data e.g. the Norwegian standard NS 3454 [12], the classification used by Danish Facilities Management [13], and the Dutch standard NEN 2748 [14].

Fourth, experiences showed that the difference between 'Operation', 'Maintenance' and 'Development' was not well understood in practice. Since the definitions of these services were critical with respect to negotiating maintenance budgets, to determine rent levels, tax regulations etc., special attention must be given to define these services.

Table 1: Definitions of main services in the proposal for a common Nordic cost classification.

No	Main service	Definition
1	CAPITAL	All investments towards completion including decommissioning by the end of use of the facilities.
2	ADMINISTRATION	Activities for administration, required payments and insurance costs.
3	OPERATION	This account includes daily, weekly and monthly activities that are repetitive within a one-year period for building and technical installation systems that must satisfy given functional demands and requirements.
4	MAINTENANCE	This account includes all activities and efforts put forward in a period of more than one year. For example, planned maintenance, replacement and emergency repairs, so that the building and technical systems satisfy the original level of quality and functional requirements.
5	DEVELOPMENT	This account includes activities as a result of a change in the demand of core activities, the authorities, total refurbishment, or all activities to raise the construction standards in relation to the original level.
6	CONSUMPTION	This account includes resources in terms of energy, water, and waste handling.
7	CLEANING	All activities inside and outside needed to meet cleaning demands satisfactorily.
8	SERVICE	All non-building related activities in support of the core activities.

The main services are defined in Table 1. ‘Capital’ concerns all costs related to the acquisition of the building. ‘Service’ concerns non-building related services. The remaining 6 main services are building-related services. In Appendix A, the classification of life cycle costs is described further on a two-figure level. Various activities are at present being undertaken in order to implement this cost classification.

5. Depicting the cost/value ratio

The ability of the stakeholders to act in accordance with lifetime considerations depends among other things on whether useful methodologies and tools exist to depict the cost/value ratio. A number of different tools and methodologies from each of the Nordic countries and the experiences with their use in practice were scrutinised. In Figure 2 an overall typology of tools and methodologies are given. The list is not necessarily exhaustive.

	VALUE for	MONEY
Investment	Market analyses	Cash flow analyses
Building process	Value management	Life cycle costing
Operation and maintenance	Customer satisfaction analyses	Operation plan and budget

Figure 2: Types of tools and methodologies.

Two features were striking. First, the scope of most of the methodologies and tools focused on either value/quality or cost. Second, the application of most of the methodologies and tools focused on one overall phase in the building’s life cycle. Although some methodologies and tools could eventually overlap, the methodologies and tools would rather be complementary. Since the mutual integration of methodologies and tools was remarkably small, it would be difficult to assess whether the client got ”value for money” or not. Therefore, one of the great challenges in the future will be to develop tools and methodologies which can appropriately depict the cost/value ratio in order to guide more informed decisions.

6. Conclusions

A Nordic project was carried out during the past three years in order to create a stronger convergence of life cycle economics in the Nordic countries. The purpose of the project was to establish networks for knowledge exchange and to develop a common Nordic approach to life cycle economics. Three conclusions were reached.

First, it is suggested that the configuration of the roles as client, owner and user is indicative for the interest of a client in life cycle economics. Three configurations were identified: 1. Client only – labelled the Hit-and-Run Client. 2. Client-owner – labelled the Landlord Client. 3. Client-owner-user – labelled the Integrative Client.

Second, a proposal for a common Nordic cost classification was put forward. The proposal was based on, but extended, existing cost classifications and data. Costs were classified in 8 main groups of services: 1. Capital. 2. Administration. 3. Operation. 4. Maintenance. 5. Development. 6. Consumption. 7. Cleaning. 8. Service.

Third, a number of tools and methodologies available to the construction and real estate cluster were scrutinised. The tools and methodologies were categorised according to their scope and application in the life cycle of the building. A striking feature was the relatively weak coupling of costs and value/quality. Thus, it is argued that there is a strong need to develop tools and methodologies that can depict the cost/value ratio more appropriately.

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The authors would especially like to thank the co-editor of the final report [8] Svein Björberg (Multiconsult, Norway) and the co-authors Björn Marteinsson (Rabygg, Iceland), Christer Sjöström (KTH Gävle, Sweden), Sakari Pulakka (VTT, Finland), and Kirsten Lindberg and Stein Rognlien (Statsbygg, Norway). The authors also wish to thank Nordic Innovation Centre for financial support.

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Appendix A
Classification of Life Cycle Costs

1	**Capital Costs**	
11	Project costs	This item includes all investments up to the finished construction. It can be subdivided into contractor costs (similar to enterprise costs), employee costs (fees, etc) and special costs (taxes, etc). It will be outlined that the contractor's costs can be divided into groups with the same rate of depreciation (see attachments). Land cost should be included. If this is a yearly fixed fee, it should be calculated to net present value.
19	Remaining costs	Costs for elimination of construction at the end of its useful lifetime. This can also be the period of use. In some circumstances the remaining costs can be income. For example, the sale of the used construction materials for new projects or the whole building for new use.

2	**Administration Costs**	
21	Taxes and fees	Property tax and other required official fees (and independent expenditures) even if the structure is not in use.
22	External fees	This item includes external assistance fees to the management, e.g. condition survey, legal assistance etc.
23	Administration and management	Salary to administrative employees. It also includes rent of space for the use of management department, documentation of the construction inclusive the management of data based system for MOMD, the service desk, marketing, internal control, etc.
24	Insurance	This item includes fire and burglary. It also includes insurance for necessary building equipment to the management department. Casualty insurance and personal property of user is not included under this insurance.
29	Miscellaneous	Example equipment for operation department.

3	**Operation Costs**	
31	Operation and inspection executed by own employees	Salary and all payments to employees (excluded are administration, see Account 2) including work clothing, materials and equipment (includes car costs, trailers, etc), tools, etc. Work assignments worth mentioning: lubrication, adjustments and regulation of technical systems, fire protection, etc. including filters, bulbs, straps, etc.

32	Operation and inspection executed by external companies	This item includes all external agreements (service agreements) for operation and supervision of elevators, fire alarms, sprinkler systems, ventilation systems, etc.
37	Outdoor operation and inspection executed by own employees	Salary and all payments to employees (excluded are administration, see account 2) including work clothing, materials and equipment (includes car costs, trailers, etc), tools, etc. for snow removal, landscape services, operation of technical construction and systems, etc. (does not include parking buildings).
38	Outdoor operation and inspection executed by external companies	This item includes all outdoor works and agreements like snow removal, landscape services, operation of technical construction and systems, etc. (does not include parking buildings).
39	Miscellaneous	

4	**Maintenance Costs**	
41	Periodical maintenance of exterior of the building	This item includes work on the façade and roof that is necessary to prevent decay of normal wear and tear.
42	Periodical maintenance of internal of the building	This item includes work on the interior of the building to prevent decay with normal wear and tear, for example painting.
43	Replacement of exterior	This item includes work and efforts that are necessary in order to accomplish replacement of exterior building components (roofs and facades). Replacement is relevant when periodic maintenance no longer satisfy maintaining technical and functional demands (parts of the building that have shorter lifetime than the rest of the building).
44	Replacement of interior	This item includes work and efforts that are necessary in order to accomplish replacement of the interior of the building. Replacement is relevant when periodic maintenance no longer satisfy maintaining technical and functional demands (parts of the building that have shorter lifetime than the rest of the building).
45	Emergency repair work for exterior	This item includes work and efforts that are necessary to correct unforeseen situations. Includes emergency efforts to the façade and roof and aligning of damages.
46	Emergency interior repair	This item includes work and efforts that are necessary to correct unforeseen situations. Includes emergency efforts to the interior and aligning of damages.
49	Outdoor	Periodic maintenance and replacement of building components including technical systems i.e. fountains, asphalt, trees and bushes, fences and retaining walls. (Does not include parking buildings).

5	**Developing Costs**	
51	Development and upgrading of exterior of the building	This item includes costs for ongoing efforts caused by new demands from the authority or core business related. For example, new fire or environment regulations or core business related. Does not include total refurbishment*.
52	Development and upgrading of internal of the building	This item includes costs for ongoing efforts caused by new demands from the authority or core business related. For example, new fire or environment regulations that gives retrospective force and thereby includes all buildings and simple rebuilding (moving doors, spatial walls, etc). Does not include total refurbishment*.
59	Development and upgrading outdoor	This item includes costs as followed by demands from activity, the authority or in connection with total renovating that will elevate the quality. Does not include total refurbishment*.

*: Total refurbishment (renovation) to accommodate new demands, new users, modernisation, etc. Is to be seen as new capital costs (a new project).

6	**Consumption Costs**	
61	Energy	All costs related to energy supplies including oil, electricity and heating.
62	Water and Drainage	All costs related to water consumption including intake water, waste water including cleaning
63	Waste Handling	This item includes all costs from internal transport, compression, source separation, collecting (hired container), transporting related to waste and taxes for landfill.
69	Miscellaneous	

7	**Cleaning Costs**	
71	Daily/Periodic	This item includes daily and weekly cleaning of all surfaces, including accessories and equipment.
72	Main cleaning	This item includes costs to periodic main cleaning, including accessories and equipment.
73	Special cleaning	This item includes, for example, floor waxing, etc. And includes accessories and equipment.
74	Window cleaning	Periodic interior and exterior window cleaning when this usually gets charged to the owner of the building or respective user.
75	Façade cleaning	Costs for façade cleaning including all necessary help. Usually performed in connection with exterior window cleaning.
79	Outdoor cleaning	This item includes cleaning of cultivated areas. Maintenance of green areas is not included. (See 3 Operation).

8	**Service Costs**	
81	Security and safety	Security outside the reception area during normal working hours. Boundary protection of the building includes operation of entry points, production of entry cards, etc.
82	Reception/switchboard	Total salary costs include social benefits, uniform and service agreements.
83	Mail	Total salary costs, postage, local transportation, operation and maintenance of the postal equipment.
84	IT service	Total salary costs, operation and maintenance of all equipment.
85	Moving	Total salary costs, transportation, extra maintenance and renovation.
86	Catering	Total salary cost to in-house and/or contract personnel, operation of automated machines, products and articles of consumption of the kitchen and rent of space.
87	Accessories/copying	Total salary costs, office and data accessories, internal and external copying, machines and equipment (rentals and service) papers, etc.
88	Administrative support	Total salary costs for in-house or support personnel (doesn't include administrative personnel in main activities (core business)).
89	Furniture and inventories	Total salary costs, purchasing and depreciation of furniture and inventory. Include rent of storage room.

Total LCC and Probabilistics

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Abstract

This paper presents a summary of the ongoing international and European activities related to LCC and sustainable construction. In particular this paper describes the ongoing development towards **Total LCC** to cover not only the initial capital and direct future costs of a building or another constructed asset but also externalities and intangibles (occupational, locational, environmental and societal costs), as well as towards **LCC with Probabilistics – LCCP** to replace deterministic (read: historic singular) values for costs and performance (read: service life) with a probabilistic approach.

Keywords: Sustainable, Life cycle costing - LCC, Monetarisation, Discounting, Probabilistic

1. Introduction

LCC and different other life cycle techniques and activities (standards & norms, requirements, technologies, theories, methods, software etc) are emerging today the most important development within the Construction and Real Estate Cluster - CREC in Finland, Europe and the world. Yet, it appears that the lack of knowledge and misconception are prevalent within the decision-makers and experts alike, as well as the various CREC stakeholders.

§ A lot of work is done at all levels. Often, however, this work seems to be insular and growing on a national or other narrow basis. Internationally recognised standards and practices should be developed; ISO, CEN. This is particularly true for the EU15 and the whole EU25 to fulfil the objectives of the open internal market.

§ New methods should be developed for the ease of understanding and application. Monetary values in Euros or Dollars are easy to understand instead of different ratings, scorings and points. For LCC and other life cycle techniques to become widely accepted, concerns about uncertainties in forecasting must be overcome: (1) costs and (2) performance of a building or another constructed asset; its components, assemblies and systems over its life.

§ All the above development is necessary to achieve sustainable construction, and it affects directly to the business environment of the CREC industries. The expected results of this development are good for investors/developers/owners, designers, contractors, facilities managers, users and other stakeholders.

2. What About Sustainable Construction?

2.1 What Is Sustainable Development?

"Sustainable development is a matter of satisfying the needs of present generations without compromising the ability of future generations to fulfil their own needs" [Brundtland report, *Our Common Future*, 1987]. Sustainable development means sustainability not only ecologically (= environmentally) and economically but also socially and culturally.

Lately in the EU and UN, an expression "the three pillars of sustainable development" is often used; the pillars are said to concern economic, environmental and social development. For not to forget cultural aspects, they should read economic, environmental and societal (= social, cultural, ethical etc) development.

Now it appears that also ISO in its fresh documents, eg ISO/CD15392 Sustainability in Building Construction – General Principles *(23 Dec 2004) [1], seems to cement its approach on these three pillars and tries to extend the meaning and contents of "social" to be equal to "societal". This writer looks like giving up but is not satisfied: For a nation, language is the most important aspect to survive, yet it is not even mentioned; without its own Finnish language manifested in 1861 there now would be neither Nokia nor Finland at all as an independent country!*

After Kibert's definition 1994, for sustainable construction CIB W82 (OT a member) proposed the following definition 1998: "The creation and responsible management of a healthy built environment based on resource-efficient and ecological principles" [2]. This definition is not satisfactory, as it leaves out economic and societal issues completely! A later programme document *Agenda 21 on Sustainable Construction* (CIB Report Publication 237, 1999) [3] adds some considerations to it, yet a better definition is needed.

2.2 Could this be sustainable construction?

The ways in which built structures are procured and erected, used and operated, maintained and repaired, modernised and rehabilitated, and finally dismantled (and reused) or demolished (and recycled), constitute the complete cycle of sustainable construction activities.

Minimise the use of materials, energy and water and mobility (factor 4/10; NL: factor 20).

Building products should, as far as possible, be reusable and materials recyclable. Design for long service life (and durability) is superior to design for reusability. Reusability is superior to recycling, and recycling is superior to waste disposal. In sustainable construction, reusability and ease of changeability are necessary product properties, in particular for modular products and systems with different service lives.

According to *ISO/CD15392 Sustainability in Building Construction – General Principles* [1], eco-efficiency is typically achieved by following the seven basic guidelines: • reduce the material intensity of goods and services • reduce the energy intensity of goods and services • reduce toxic dispersion • enhance material recyclability • maximise sustainable use of renewable resources • extend product durability • increase the service intensity of products.

2.3 Why sustainable construction is important?

In advanced European vocabulary "construction" is considered to cover the entire value chain of develop/own, design, manufacture, construct, recycle a building, infrastructure or other constructed assets. Today in Finland and elsewhere, a new expression Construction and Real Estate Cluster - CREC has been taken to use to cover all activities directly related to construction and real estate (buildings, infrastructure and other facilities = 60-70% of the national wealth). Compared to the above, CREC covers the whole life of a building, hence additional activities concern running the building, which more often is done by facilities management.

A reason to this approach is the fact that major contractors are moving from plain construction towards taking care of the building/facility for its whole life. Also public-private partnership projects (BOOT, PFI; toll roads & bridges, schools, prisons etc) require this approach. All investors and property developers need this. And any sustainable construction consideration requires CREC!

While in Finland construction represents 10% of GDP (or 12% if repairs & refurbishment are counted in), CREC represents over 30% of the same GDP (CRECgdp= 37GEUR= 26%). Accordingly, in the EU15 construction represents 10% of the total GDP, and CREC a quarter of the same GDP!

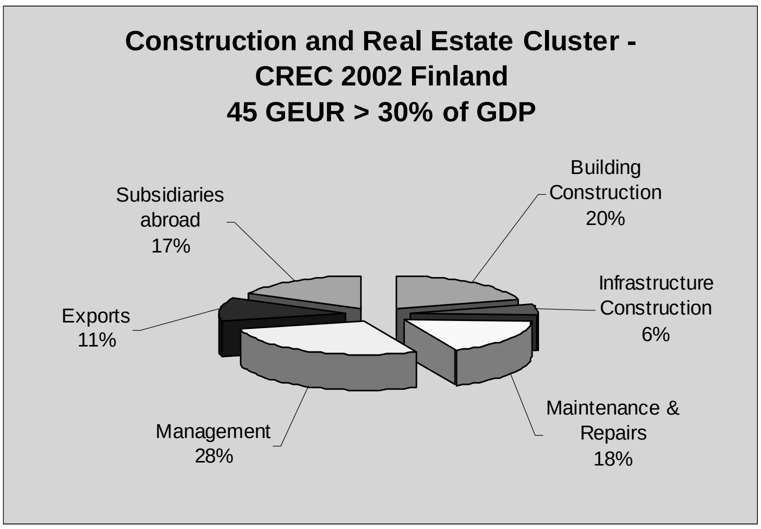


Figure 1 CREC, year 2002 Finland (source: VTT)

By weight, construction activities consume up to 50% of all raw materials used and produce over 40% of waste (yet, mostly recyclable, and reducing rapidly in enlightened countries). Buildings consume 40% of total energy and account for 30% of CO_2 emissions, thus environ-mentally alone, CREC's sustainability is most important for whole society!

3. What are LCC and LCA?

3.1 Definitions

It is important to understand the fundamental differences between LCC and LCA:

Derived from ISO 14040: In CREC, **environmental life cycle assessment - LCA** is for assessing the total environmental impact associated with a product's manufacture, use and disposal and with all actions in relation to the construction and use of a building or another constructed asset. LCA does not address economic or societal aspects!

Derived from ISO 15686: In CREC, **Life cycle costing - LCC** is a technique which enables comparative cost assessments to be made over a specified period of time, taking into account all relevant economic factors both in terms of initial capital costs and future operational costs. In particular, it is an economic assessment considering all projected relevant cost flows over a period of analysis expressed in monetary value. Where the term uses initial capital letters it can be defined as the present value of the total cost of an asset over the period of analysis.

3.2 ISO 15686 - Service life planning

Very important standard development is taking place in the newly reorganised ISO technical committee TC59 "Building construction", particularly in its subcommittee SC14 "Design life". The series *ISO15686: Buildings and constructed assets - Service life planning* is rapidly offering new tools for the life cycle planning of buildings or other constructed assets. So far this series covers 10 parts: the first 4 parts are ready and the remaining parts advanced, and the first part "umbrella standard" already under revision.

This writer considers this development positive and important. Unfortunately the work done on "Part 5: Life cycle / Whole life costing" has produced totally confusing, derailed papers in contradiction with the umbrella standard. The confusion lingers about the introduction of Whole Life Cost(ing) – WLC, a British wording, to replace internationally recognised Life Cycle Cost(ing) – LCC (the work is headed by British Standards Institution - BSI). Also the arithmetics used diverts from commonly known and understood formulas. This all is to alienate the prospective users from the new standards.

Finland has been against the various drafts of Part 5 and requires its total rewriting (eg 04 May 2004: "... not in favour of sending 15686-5 to DIS Enquiry" and "Delete all references to whole life costing". Voting took place Oct 2004: 8 in favour, 3 = Nordic countries against, 5 abstained.

3.3 LCC in Construction – New EU reports

In late 2001, a task group TG4 (OT a member) was established by the EC DG Enterprise to "Draw up recommendations and guidelines on Life Cycle Costs - LCC of construction aimed at improving the sustainability of the built environment". The group tries to find models for practical application of sustainable construction based on present value – PV of economic and environmental factors. Societal factors (social, cultural, ethical etc) were unfortunately left out.

The final report *Life cycle costs in Construction* [4] was approved 29.10.2003 in a tripartite meeting in Brussels, comprising representatives from the Commission, member states and industry (OT a member). The paper, printed July 2004 and supposedly distributed to all member states, makes seven recommendations to advance the use of LCC. <u>This guide discarded WLC as globally unknown, confusing and misleading, and sticks to LCC and commonly used formulas for calculation</u>, as presented in the following pages.

A new Communication from the European Commission titled: *Towards a thematic strategy on the urban environment* came out 11 Feb 2004 [5]. It is the first step towards the EU's Sustainable Urban Environment Strategy. This new report was prepared by independent experts from CREC and commission officials. It covers four domains: management, transport, construction and design. It correctly recognises that sustainability is not about environment only but also economic and societal impacts should be duly considered; elements such as life cycle costs, indoor air, noise, accessibility, comfort and risks (others can be easily added). To a major extent it is built on the earlier documents. This document is to create further actions in the EU and CEN towards related regulatory guidance and standards.

3.4 New CIB reports

Late March 2004, a pretty comprehensive *Performance Based Methods for Service Life Prediction - State of the Art Reports* (CIB publication 294) [6] was completed by CIB W080 / RILEM 175 SLM Service Life Methodologies - Prediction of Service Life for Buildings and Components. It covers two parts, Part A - Factor Methods for Service Life Prediction and Part B Engineering Design Methods (EDM) for Service Life Prediction. As conclusion and outlook it reads: As opposed to using simple numerical factors in the original factor method, this (EDM) approach <u>incorporates the use of probability density functions for factors as well as for the service life of individual components</u> to arrive at an overall estimate of a building's service life.

Early April 2004 came out also a related publication *Guide and Bibliography to Service Life and Durability Research for Building Materials and Components* (CIB publication 295) [7] completed by Joint CIB W080 / RILEM TC 140 - Prediction of Service Life of Building Materials and Components. This report, published in five parts totalling 377 pages and 5.7 MB, contains fundamental knowledge on service life prediction and related topics. Among other things, the report is stating that the service life cannot be expressed as a single deterministic value but described in stochastic terms with the aid of a probability density function.

4. Total LCC – the ultimate solution

4.1 Can LCC and LCA be put together – No!

LCC gives you figures in money for any present and future costs for a period of analysis, as required. LCA may be used to create regulatory requirements, offer incentives and determine rating/scoring systems to help decision-making. LCA does not give you any figure in money.

Eg, in the case of tenders, considering construction cost as usual plus LCC calculations plus LCA scoring, you should be able to calculate LCC + LCA ie a total = money + points! No existing related software gives you any proper consistent solution to this equation. My initial conclusion is no, LCC and LCA cannot be put together (3 apples + 2 oranges = 5 fruits, but 3 Euros + 2 points = nil). Studies and efforts done in the EuroLifeForm project (see later) proved that this is not realistically possible!

4.2 Total LCC is the answer

To overcome this LCC + LCA problem, I try to look at it purely arithmetically. In the book *Construction Can!* published by arrangement of ENCORD (European Network of Construction Companies for Research and Development) in 1998 [8], I introduced a fresh approach to LCC to cover not only the initial capital and direct future costs of a building or another constructed asset but also externalities and intangibles (occupational, locational, environmental and societal impacts), as shown in the figure below.

To put it simply, Total LCC just tries to convert all various LCA impacts to money. After this monetarisation everything can be calculated mathematically as LCC = NPV of all effective costs over the period of analysis. Think this is impossible? For mobility this is easy and customarily done. For occupational factors more and more studies are coming out eg in the USA, Finland etc showing the value of various office properties/ features in productivity and expressed in monetary terms. Eg for environmental LCA impact, the environmental profiles of construction materials, components and elements are in a good progress in the UK, Denmark, Finland and elsewhere. These profiles already have been converted to Ecopoints (GB) or equivalent CO_2 (DK) or CO_2 plus full profile (FI). After this, monetarisation shouldn't be impossible. Measuring the monetary value of something does not require that it be sold and bought in markets. Today this monetarisation seems to attract more attention, particularly in the USA.

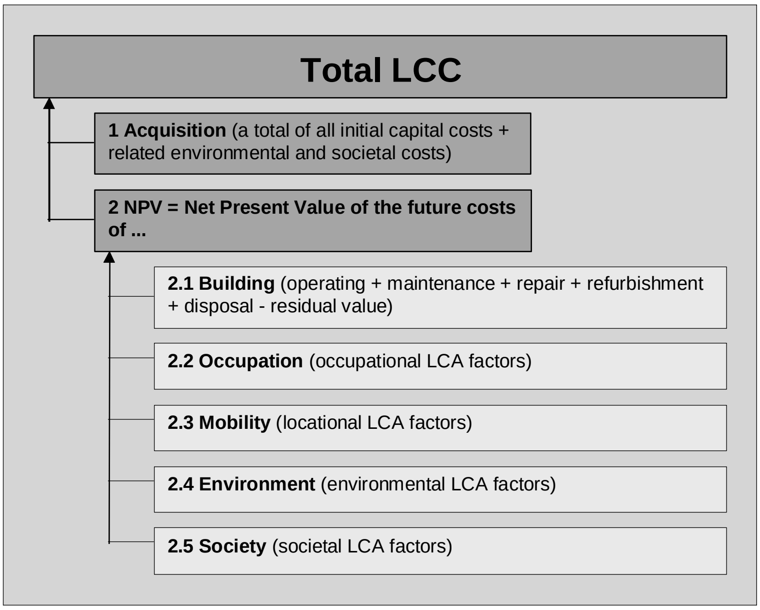


Figure 2   Total LCC – monetarising all impacts

Acquisition (capital costs + environmental and societal costs) refer to costs directly related to the whole building and its components and assemblies, including planning, design, construction, installation, fees and charges and other acquisition costs, plus related environmental and societal costs.

NPV = Net Present Value of the accumulated future costs over a period of analysis, as described below. Period is determined as per the planned/ongoing activity and can be whatever up to the end of the service life of the building.

Building (operating + maintenance + repair + refurbishment + disposal - residual value) refers to the future costs of all the different activities necessary to run the building over a period of analysis.

Occupational factors refer to health, comfort, productivity, safety and security of the building (eg office). It is here important to realise the relationship of different accumulated costs for an office building with eg 30-year ownership:

- 1 : 5 : 200
- 1 = acquisition
- 5 = building operating and maintenance (see 2.1 above)
- 200 = business operating costs → here the biggest benefits are easiest to achieve through better comfort and productivity → good indoor environment/climate/air.

Example Finland - *Productive office 2005* (final report 2004):

- **High office temperatures**: 1 person per room; work value 50kEUR/a:

- Before: Temp max = 32.7C; 890Ch >25C [optimal 21…25C = reference temp; productivity loss percentage = 2*(t-25)%]
- Productivity loss = 330EUR/a
- Improvement: Centralised cooling 20W/m2, usage increased 10 ð 24h/d
- Investment: 316EUR/room; annual cost = 35EUR/a
- Increased energy cost: 68EUR/a
- After: Temp.max = 27.3C; 51Ch >25C
- Productivity loss = 19EUR/a
- Improved productivity: 311EUR/a (= 0.6%*50kEUR/a)
- Beneficial return: 208EUR/a (= 311-68-35)
- Occupational impact monetarised, and improvement profitable!

In the Finnish case study object Intentia HQ, a **Post Occupancy Evaluation – POE** was performed utilising the BUS method from the UK, licensed by Villa Real; report is available free of charge in our online bookshop at www.villareal.fi/.

Mobility, hence locational factors refer to the location of a (industrial, commercial, office, school etc) building. We should calculate LCC not for the building alone but also its location in relation to incoming material and outgoing product flows, employees' daily commuting, customer traffic to a shopping centre, or school children's daily transport, ie the mobility the building is causing.

Example Finland - *Road traffic costs* (2000/2005), simplified:

- **Travel to/from work**: by car, alone; 20km, 30min
- Vehicle cost: 0.40EUR/km (private/company car), 0.15EUR/km (society)
- Time cost: 31EUR/h (private/society)
- Mobility cost = 16.00/47.00EUR/d (private)
    - = 16.00EUR/d (company)
    - = 6.00/37.00EUR/d (society)

⇒ Locational impact monetarised!

Environmental factors refer to different environmental impacts that various materials and actions cause; environmental profiles. Environmental factors still need quite a lot of RTD at European and international levels to define their features and properties and, to give them generally accepted monetary values.

Example Finland - *Environmental declaration of building products* (2004):

- Environmental profile - altogether 31 properties defined & quantified
- **Ormax concrete roofing tile**, manufactured by Lafarge Tekkin Ltd
- Emissions to air (10 prop.) - CO2: 0.129kg/kg = 129kg/ton
- European (Kyoto) market price for CO2 = 10 EUR/ton
- Environmental impact cost = 1.29EUR/ton = 0.006EUR/tile (@4.3kg)

⇒ Environmental impact monetarised!

Societal factors finally need to be taken into account. This area is very little covered so far. Yet, for the CREC industries, cultural and other societal phenomena are necessary every-day considerations (eg concerning a new road through a village).

§ It is important to realise that it is not environmental LCA factors only to count in. And, that without economic considerations, there is no future for environmental LCA considerations.

Finally, a probabilistic approach could be incorporated in all impacts and all costs, delivering a Total LCCP (using @Risk 4.5 and Monte Carlo/ Latin Hypercube simulation).

All the above is being carefully studied in the PhD work of this writer at Helsinki University of Technology, to be concluded early 2006.

4.3 How to calculate LCC

The Net Present Value – NPV (I prefer to use Net Present Value - NPV instead of less familiar Present Value – PV) procedure reduces a series of cash flows which occur at different times in the future to a single value at one point in time, the present. The technique which makes this transformation possible is called discounting. LCC is calculated as NPV of the accumulated future costs (C) over a period of analysis (t), eg 25 years (N), at an agreed discount rate (d), eg 1% (= 0.01) pa dependant on prevailing interest and inflation rates. NPV is calculated according to the following formula, and can be done with eg Excel (up to 29 years easily...)

$$NPV = \sum_{t=0}^{N} \frac{C_t}{(1+d)^t} \tag{1}$$

NPV can be calculated using nominal costs and discount rate based on projected actual future costs to be paid, including general inflation or deflation, and on projected actual future interest rates. Nominal costs are generally appropriate for preparing financial budgets, where the actual monetary amounts are required to ensure that actual amounts are available for payment at the time when they occur. NPV can be calculated also using real costs and discount rate, ie present costs (including forecast changes in efficiency and technology, but excluding general inflation or deflation) and real discount rate (d_{real}), which is calculated according to the following formula, where (i) = interest rate and (a) = general inflation (or deflation) rate, all in absolute values pa.

$$d_{real} = \frac{1+i}{1+a} - 1 \tag{2}$$

To make the LCC approach significant for improving the sustainability of the built environment and the related calculations easier to understand, real costs and discount rate are useful. At low discount rates long-term future costs and savings are meaningful also at present.

4.4 What discount rates for what economies?

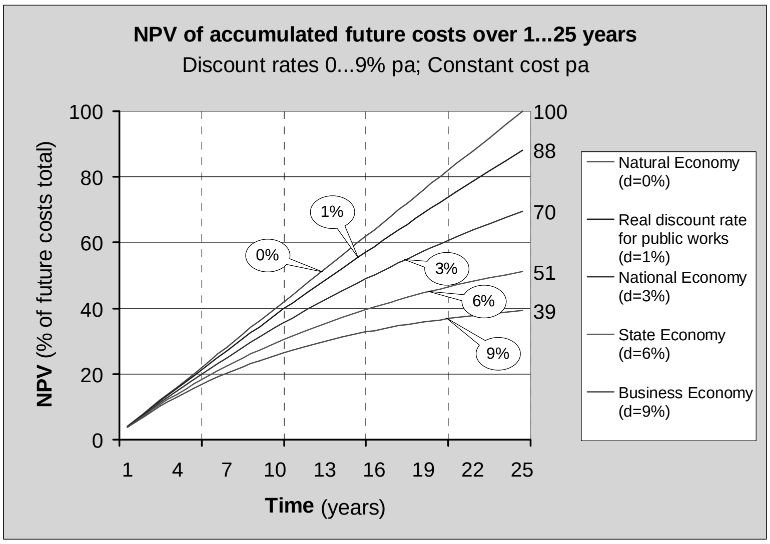
Problems and observations: LCC = NPV calculations should be easy, it is just arithmetics. Yet, after my seven years' research, it appears that the lack of knowledge (note: noise→ data→ information→ knowledge→ wisdom) and misconception are prevalent within the decision-makers and experts alike, as well as the various CREC stakeholders. Some examples follow, mainly concerning Public Private Partnership - PPP projects funded by tax payers' money: • Wide variation on the discount rates used; in EU25/10a: 2...12% pa. • Constant discount rates used unchanged for years, although the actual rates have fluctuated >50%; eg the UK 6% pa. • Generally too high discount rates used, which makes future costs/savings meaningless; In EU11/10a: interest rate i=3%, general inflation a=2% → discount rate d_{real}=0.98%. In EU25/20a: d_{real}<0% in several years. In Finland today a family house mortgage: i=3.7% (5a fixed) / 3.3% (weighted average), a=0.8% → d_{real}=2.88 / 2.48%. • Real (ie today's) discount rate used together with nominal (ie future) costs; wrong formula leads to wrong/meaningless results. • Nominal discount rate used together with real costs; wrong formula leads to wrong/meaningless results. • In some PPP project invitation documents (eg in the UK) the client has left the discount rate open. Thus the tenderer must present their own discount rate as part of their tender; here the tenderer may take an additional calculated risk (probabilistics with different scenarios and sensitivity analyses help). To avoid major failures, here all stakeholders must thoroughly understand the concept the same correct way.

Discount rate is important: For any long-term (investment) calculation discount rate is necessary. Simple payback is too crude, and too high discount rate nullifies the future costs/savings. Thus a correct discount rate must be used. • For any professional investor the use of discount rate is a must. The rate used depends on the return of investment required/expected. • In sensitivity analyses discount rate is often one of the most sensitive determinants. • For PPP projects real discount rate and real costs should be used. For the good of society and to avoid escalating future operating costs, optimally d_{real}=1...2% pa in the today's EU11 economic environment. • A winner can be always selected at whatever predetermined discount rate, yet the eventual outcome may be disastrous for the stakeholders and society! Particularly so, if too high d_{real} or wrong formulas are used.

The net present value - NPV of accumulated future costs depends on the used discount rate(s). In the following chart I introduce four "rooms" of different stakeholders. For each room a certain level of nominal discount rate is applicable, dependant on the return of investment required/expected by the particular stakeholder. These rooms I descriptively call **Natural** (d=0% = simple payback), **National** (3%), **State** (6%) and **Business** (9%) Economies. The chart shows how NPV is accumulating over 1…25 years in each room/economy at their respective nominal discount rates. In addition, I offer 1% pa as a suitable real discount rate for public works in EU11 today.

Figure 3 NPV of accumulated future costs in different economies

The actual rate of return available through LCC considerations on the operating costs of



buildings and other constructed assets today may be lower than that offered by alternative long-term investment: as a nominal annual rate of return, stock market 15% (-90% for .coms → risk), 9% business ROC/ROE (→ risk), 6% bonds, 3% bank deposits. Yet, buildings, roads, bridges and other constructed assets have long service lives. At low discount rates long-term future costs and savings are immediately meaningful, as can be seen in the above figure at 1% rate. Then investment for the better future looks more rewarding. Also, it can be claimed that future operating costs will be increasing due to higher energy prices and new environmental and other regulatory requirements. This development will raise the calculated return in Euros or Dollars and may enable market-driven LCC considerations. And, often the investment for lower operating (eg energy) costs is only marginally higher than for a "standard" design.

5. Probabilistics to replace deterministic values

For LCC to become widely accepted, concerns about uncertainties in forecasting must be overcome: costs and performance of a building, its components and assemblies. An important European RTD project **EuroLifeForm** is to develop a design methodology and supporting data, using a probabilistic approach, with a budget of 3.8 MEUR over 2001…04. Villa Real (FI) is the originator and a major partner, and Taylor Woodrow (GB) the coordinator. The newest theories and software are used for probability, risk, sensitivity analyses and optimisation (@Risk 4.5 Industrial using Monte Carlo/ Latin Hypercube simulation) and for complex multi-objective/ multi-criteria decisions (Logical Decisions 5.1). In all seven partner countries data and information is collected; generic and on 11 case studies

The principal outcome will be a model for LCC with Probabilistics - LCCP, in a software format, to replace deterministic (read: historic singular) values for costs and performance (read: service life) with a probabilistic approach, good for investors/developers/owners, designers, contractors, facilities managers, users and other stakeholders. Plus a stint of environmental LCA incorporated. As an example, a contractor can use LCCP software in his tendering for a BOOT or other type PPP or private project. As shown in the chart below, he is able to make a well informed decision on the final tender price based on probability, or risk he is ready to take. Risk involved he can also reduce by scenarios and more accurate source data.

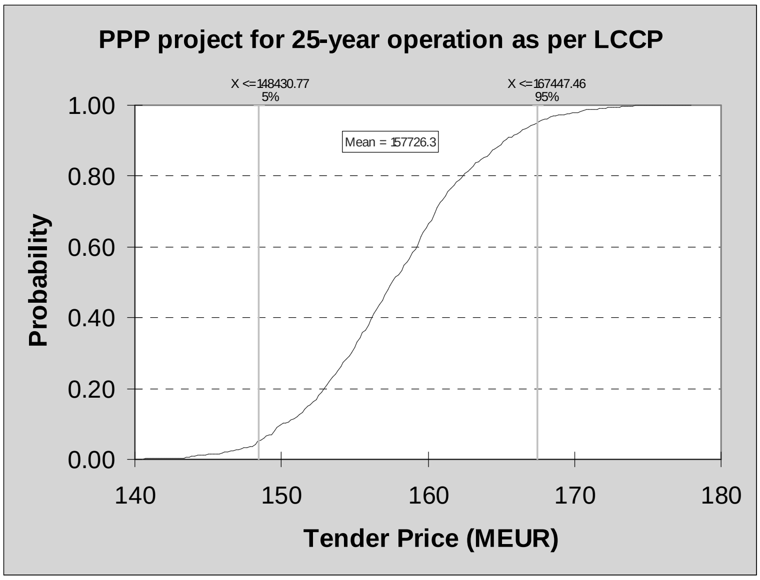


Figure 4 The outcome of tender computing utilising LCCP Wise™ software

A pack of models to enable a lifetime design process utilising the LCCP approach was developed. The under-listed related software tools are now near completion, soon ready for national customisation, commercialisation and consulting services. Visual Basic 6 is utilised to increase versatility, enable integration and to improve user friendliness. The integrated pack and its modules are wiser than the insular deterministic methods currently in use. Thus the name **LCCP Wise™** for the software pack.

§ **LCCP GateWise**: A gateway to the other LCCP tools, registries for computation results & decisions made, and database repositories.

§ **DB LifeWise**: Database with min/most likely/max reference service life values for building elements (components, services, parts).

§ **LCCP LifeWise**: Deterioration model at @Risk & Excel, utilising ISO 15686-1 factor method. It provides estimated service life for replacement, as expected in the particular project on hand, plus data for planned preventive maintenance and reactive maintenance, all in a probabilistic format. Integrated with LCCP AllWise.

§ **DB CostWise**: Database with min/most likely/max cost values for building elements (components, services, parts). Usually this data is highly commercially sensitive, kept secret and not available for the public. Contractors, quantity surveyors etc can use their own data.

§ **LCCP AllWise**: A calculator at 3 levels, Client brief, Concept design and Detailed design based on @Risk, most important.

§ **LCCP EnvWise**: Excel-based screener to assess environmental impact.

6. Conclusions

Where we are today: • Acquisition capital costs govern. • LCC is up and coming, today mainly for future energy costs. • Probabilistics is new and “difficult”. Yet, advanced CREC partners are already applying it. • Total LCC gives valid answers easy to understand. • This writer is confident that eventually the Total LCC/LCCP will be taken to use in the EU. It was already initially approved in 2001 by the task group TG4 of the EC DG Enterprise!

Updated information, my various publications plus the EU documents mentioned, all are available at http://www.villareal.fi and http://onlinebookshop.villareal.fi.

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Live Cycle Cost Optimisation and Rational Cash Flow

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Abstract

Construction works, and investment as such, particularly expensive parts of them, are a field where the *Live Cycle* approach can be and should be applied. Decisions about cash flow and the fixing of time schedules are decisions with long-term impact and *long-term memory*. Mistakes from the distant past have a massive impact on situations in the present and into the far economic future of economic activities. Arranging production activities to fit in with other construction activities is one of the basic ideas of the Just-in-Time (JIT) approach [1]. However, this deficit may double if the maintenance will not be optimal in their cost cycles (LCC). The solution may create the nonlinear optimisation of Cash Flows during construction and during time of capitalisation (rational exploitation). Practical examples show that the improvement in cost flow and total amount of money spend in construction and further use may be cut significantly. The calculation is based on spread sheets calculation, very easy to develop on most computers and even on note books now a days.

Keywords: Optimisation, production speed, optimal cash-flow, spreadsheets, spreadsheet solver, nonlinear optimisation, Live cycle (LC), Live Cycle Costs (LCC), long - term memory.

1. Introduction

Organising construction activities according to the latest possible internal time schedule, taking into account the organisational and technological process, is called the Just-in-Time method (JIT). This method has never been consistently applied in large investments, in large development and research projects, in the development of strategies and in maintenance schedules, in the construction industry, though this paper will argue that it should be. Time dependent (sequencing) processes in construction production are an appropriate place for practicing JIT methods.

2. Motivation

Two significant pillars of civil engineering, *Tradition* and *Experience,* have built a whole series of overt and covert myths into the civil engineering profession. Many of these relate to work organization. Some are useful and perpetuate the tradition and ethics of the profession, but many are outdated and no longer apply in the high-speed production conditions of modern construction.

This refers to the following principles (theses):

1. To build quickly (under any circumstances) means to build economically.
2. A construction manager fulfilling the earliest possible deadline is a good construction manager.

3. To build continuously means to build economically.
4. Cumbersome technologies are disadvantageous.
5. Payment for work in progress is a good principle.

From the modern construction point of view, early completion may not be either necessary or economically useful. However, the idea that *what is completed can be counted on*, has extraordinary strength in some areas of the construction industry, investments and other project with a long life cycle (LLC). The efforts of many contract managers to create a time reserve and to lower the risk of breaching the construction deadline go so far as to perform a series of works earlier than is technically and organizationally necessary.

3. Spreadsheet dynamic schedule

From a practical point of view, it is possible to get the calculation of activities duration (partial jobs) by spreadsheet calculation (see fig. 1). It is reasonable to calculate activity duration, cash flows and simulation of risks, even if some activities are risk conditioned. We may see the spreadsheet table not only as a tool for calculation but also as an expression of complex formulae [2], [3]. This approach may offer a mechanism for answers to the *sensitivity of manageable parameters* (say costs, construction speeds[1]). We scrutinize the spreadsheet not only as a matrix or as a table. $\mathbf{TAB}_{\text{project}}$ is a complex description of project conditions that enables calculations, simulations, and parameterizations for the evaluation of potential management changes. We may describe [6] a project as a table structure

$$\mathbf{TAB}_{project} = \boldsymbol{N}\left[\boldsymbol{D} = f(\boldsymbol{Q}, \boldsymbol{v}),\ \therefore Org\right] \qquad (1)$$

based on a network composition ($\boldsymbol{N}$) of duration sets of partial activities $\boldsymbol{D}$**,** quantities (costs, production volumes) $\boldsymbol{Q}$ given predominantly as costs and production speeds $\boldsymbol{v}$. Further there are specified organisational compositions (mark$\therefore$) among activities, $\therefore \boldsymbol{Org}$. The set of activity compositions given as $\therefore \boldsymbol{D}_{network}$ play the role in quantification of durations $\boldsymbol{D}$ (let us say technological connections of activities such as *Start-Start, End-Start, End-End*; combined connections like the *critical activity* approach, *Minima condition*, *Maxima condition*, and other logical connections of type *If-Then*). The conditioning in costs and other mostly legal conditions and regulations are even more sophisticated $\therefore \boldsymbol{D}$ or $\therefore \boldsymbol{Org}$ conditions in progress. We may write a more extensive notation (2) for this purpose as

$$\mathbf{TAB}_{project} = \boldsymbol{N}\left[\boldsymbol{D} = f(\boldsymbol{Q}, \boldsymbol{v},\ \therefore \boldsymbol{D}_{network}),\ \therefore \boldsymbol{Org}\right] \qquad (2)$$

Nevertheless the comprehensive open approach emphasized in this paper is based on *spreadsheets* [6], enabling the calculation of time and costs and furthermore conditioned calculations of *risks* (3).

However, the application to a real building site has his price, creates some substantial profits. The extension to real practical management decisions needs further information about risk and sensitivity to proposed managerial changes. The concise notation of the problem is given in (3) and (3a).

[1] *Duration* of activity *i* (job) will be calculated as *Costs*(*i*)/*Production Speed*(*i*), or $D_i = c_i/v_i$.

$$\mathbf{TAB}_{\text{project}} = \boldsymbol{N}\left[\boldsymbol{D} = f\left(\boldsymbol{Q}\middle|risk,\ \boldsymbol{v}\middle|risk,\ \therefore \boldsymbol{D}_{network}\right),\ \therefore \boldsymbol{Org}\middle|risk\right] \tag{3}$$

$$\mathbf{TAB}_{\text{project}} = \boldsymbol{N}\left[\boldsymbol{D} = f\left(\boldsymbol{Q}\middle|param,\ \boldsymbol{v}\middle|param,\ \therefore \boldsymbol{D}_{network}\right),\ \therefore \boldsymbol{Org}\middle|param\right] \tag{3a}$$

The parameterization paves the way to limits for management intentions and economic reasoning. The shortcut presented in (3a) round up the problem to the main corner stones [6].

Months																									Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Q
Section A																									300
30	30	30	30	30	30	30	30	30	30																
Segment A1																									100
10	10	10	10	10	10	10	10	10	10																
Segment A2																									50
5	5	5	5	5	5	5	5	5	5																
Segment A3																									40
4	4	4	4	4	4	4	4	4	4																
										Section B															200
										40	40	40	40	40											
										Segment B1															70
										14	14	14	14	14											
										Segment B2															40
										8	8	8	8	8											
															Section C										100
															10	10	10	10	10	10	10	10	10	10	
															Segment C1										60
															6	6	6	6	6	6	6	6	6	6	
															Segment C2										70
															7	7	7	7	7	7	7	7	7	7	
Section D																									250
10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	
59	59	59	59	59	59	59	59	59	59	72	72	72	72	72	33	33	33	33	33	33	33	33	33	33	1280
1,21	1,20	1,19	1,18	1,17	1,16	1,15	1,14	1,14	1,13	1,12	1,11	1,10	1,09	1,08	1,07	1,07	1,06	1,05	1,04	1,03	1,02	1,02	1,01	1,00	1280
71	71	70	70	69	69	68	68	67	66	80	80	79	79	78	35	35	35	35	34	34	34	34	33	33	1427,136

Fig. 1a Input situation, time and costs layout structure as equalised distributed resources.

Months																									Total	Total	Total Q
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Q	Q´	Limit
Section A																									300		300
300	0	0	0	0	0	0	0	0	0																	30,000	
Segment A1																									100		100
100	0	0	0	0	0	0	0	0	0																	20,000	
Segment A2																									50		50
50	0	0	0	0	0	0	0	0	0																	7,143	
Segment A3																									40		40
40	0	0	0	0	0	0	0	0	0																	5,714	
										Section B															200		200
										200	0	0	0	0												0,000	
										Segment B1															70		70
										70	0	0	0	0												0,000	
										Segment B2															40		40
										40	0	0	0	0												0,000	
															Section C										100		100
															100	0	0	0	0	0	0	0	0	0		0,000	
															Segment C1										60		60
															60	0	0	0	0	0	0	0	0	0		0,000	
															Segment C2										70		70
															70	0	0	0	0	0	0	0	0	0		0,000	
Section D																									250		250
250	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		35,714	
740	0	0	0	0	0	0	0	0	0	310	0	0	0	0	230	0	0	0	0	0	0	0	0	0	1280		
1,21	1,20	1,19	1,18	1,17	1,16	1,15	1,14	1,14	1,13	1,12	1,11	1,10	1,09	1,08	1,07	1,07	1,06	1,05	1,04	1,03	1,02	1,02	1,01	1,00	1280	max	1280
895	0	0	0	0	0	0	0	0	0	346	0	0	0	0	247	0	0	0	0	0	0	0	0	0	1488,903	1000	$\gamma = 1,1$

Fig. 1b Time and costs layout structure max - no speed limit, optimised (extreme).

4. Formulation of the optimisation problem

Let us for a moment leave aside considerations, theories and detailed analysis. Let us direct our attention to a substantial economic problem. How can the possible effects of optimisation of construction cycle and later on maintenance and renovation cycles be applied to the construction industry and investment strategies? There are two domains: *JIT in construction* => time, production live cycle speed and *JIT in maintenance* => time, investment volume, maintenance live cycle speed.

The construction understood as an organisational and technological procedure is described by a spreadsheet driven table. The practical example presented in the time schedule is the scope of fig. 1a. The scheme of construction process is divided into three main activities or sections (A, B, C, D) and their parallel work-subgroup segments. The technology of production progress has its main parts A, B, C sequenced in time. The structure of fig. 1a is original result of the construction project. The calculation of fig. 1a shows the results if the production speed has stable flow in duration of activities for an earlier mentioned spreadsheet calculation. The exact *time* and *cost* schedules are the result. The main defects, the solution in fig. 1a is the preconditioned of constant production speed or better a empirical speed given in fig. 1a for any activity. More sophisticated rescheduling might bring in return extra profit. The method for the exact solution is optimisation based on the solver in spreadsheet packages. The result is re-location of flows (work speeds, work – durations and time sequencing).

The risk analysis calculation is usually a subsequent supporting calculation. The evaluation of *potential management decisions* provided by the feasibility of parameterisation may be a further step. The evaluation of time and cost feasibility in terms of management decisions creates new limits and probable new safer horizons in decision-making.

In fig. 1b we may follow limit-result of a policy minimising risk in the finishing of activities. The earliest possible start and finish of any activity was the result. The *total costs* of project (without time factor) are given by 1280 t. €, second line down line in fig. 1a and 1b. All figures show cash flow and total costs 1280 t. €. The sum of cash flow fixed in time is given as 600 t. €, that indicates total volume might be shifted in time (see also fig. 2). This indicates a relative space for *shifts* in construction *capacity cost flow by optimisation*.

For the bank loan rate says of i = 0,10 the value of construction money during 25 months of construction time increases. There are many ways how to recalculate cost to the future costs. In the example given in the fig. 3 we use a recalculation of production speed $Q'(t)$ by means of power function γ^{t}, *where* $\gamma = 1{,}17$, γ comment on the next page. The present value of total production speed $Q_{PV}'(t)$ is given as

$$Q_{PV}'(t) = Q'(t)\,\gamma^{t} \quad (4),$$

where time decreases from the construction start in $t = -25$ (left side of the fig. 1a) to $t = 0$ in the project finish at the right side. A similar result may be given by exact calculation used in the financial calculation as

$$Q_{PV}'(t) = Q'(t)\,1/(1+i)^{t} \quad (5).$$

The alternative calculation by means of relation

$$Q_{PV}'(t) = Q'(t)\, e^{it} \tag{5a}$$

may offer also an acceptable solution for optimisation.

The total value of costs 1280 t. € will increase to 1427,136 t. € if we calculate the interest rate for 25 months and to 1443,839 t. € if we recalculate by time factor cash flow given in the second last line in fig. 1a, 1b. Time factor γ = 1,10 causes cca 11,5 % increase of total investment project costs in 25 months. This percentage indicates the costs of credit of unproductive frozen investment assets. The improved technology and organization of construction schedule is, from this point of view, economically desirable and feasible (see data in fig 2).

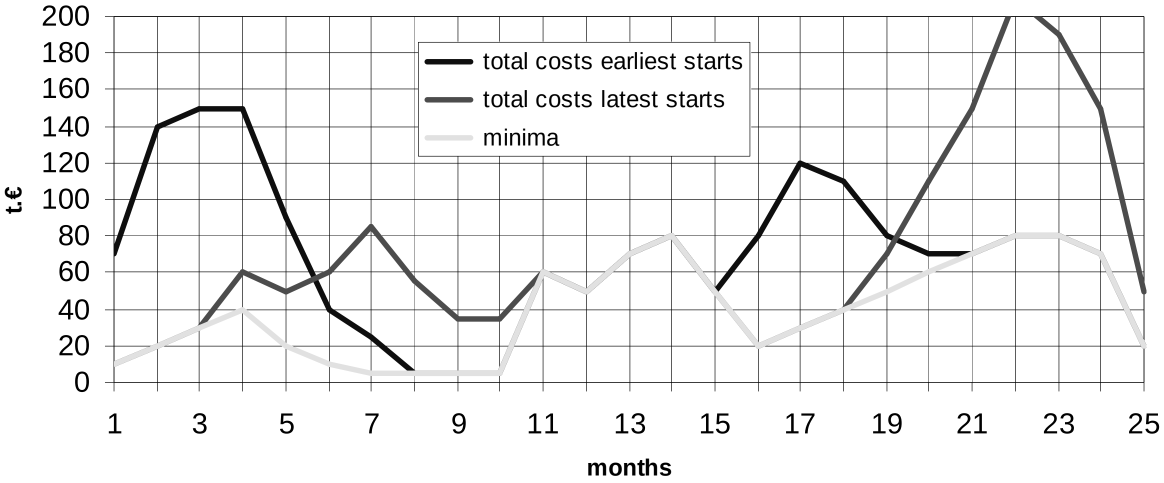

Fig. 2 Comparison of total and in time fixed costs cash flow, example.

From a mechanical point of view of possible shifts (say earliest and latest possible starts and finishes), we will get a good deal of profit. If segments (activities) A1 and A2 will slip to the time end of A section and similar segments B1, …, C1, …, D to the end of their Sections, the total latest cost flow will be gained. If we recalculate by time factor cash flow given in cash-flow for latest starts the total value of money is 1367,623 t. € (see fig.3). Moreover, if we are able to create a dynamic shape of activities, there is more space for effective rationalisation of cash flow. Optimisation may pave the way to this sophisticated efficiency. Sophistication is limited. We understand it only in terms that an optimal solution is not intuitively available.

In comprehensive thinking, there are clear reasons usually responsible for the high cost of projects

a) long construction time,
b) bad strategy of construction work sequence,
c) high cost of money (interest rate).

The construction of γ may differ for diverse projects. The new reasoning is given in guideline *Basel II* criteria. It usually includes (auditing to bank loan rate) *risk rate* and *entrepreneurial profit*. For a commercial case it might be compounded by components mentioned by γ = 0,10 + 0,04 + 0,03. The losses from frozen capital for t=15 years raise $0{,}17^{15}$ = 2,55 times capital spent for ordinary cash flow spent in construction. In East Europe the power plants such as Transportation Networks completation in towns (München, Dresden or Prague). The *s*ituation was predetermined by low production capacity (low ability to create high construction speeds[2]). There are also other reasons why construction management has shifted to other then economic rules. *Reliability* of finishing date will be the other reason. *Wrong contracting conditions,* instead of lump cost, paying according to work done, without differentiation of work due to time break down of structures. Generally, a fair break down of advantages and risks of the contracting and contracted subject might lead to more respectable economic situations.

The *interest rate* might lead us to question the robustness of this time factor constant. However, it is not the exact level of interest that moves this model forward but the optimisation of cash flow proposed for different activities. The time we have for construction is not continuous time. Construction time is the discrete time linked to limited available resources. Discussion about the level of interest rate, which is used for optimisation, is always inviting and appealing. The private business looks to protect its right to get approximately the same level of revenues as government take (see the left and right hand side of formula (4)). However, such discussions raise more questions than answers. Does lost GDP represent the main loss of unproductive frozen governmental resources? Does the above mentioned entrepreneurial point of view (γ) really contains comparable economic values? The equation concept usually has the form as

$$\textbf{capital interest rate + risk rate + entrepreneurial profit rate} \approx \textbf{GDP.} \qquad (6).$$

From an economic point of view, it is necessary to see the equation as a balance of the free entrepreneurial profit calculation on the left hand side of equation (4) and a governmental expectation or deal on money spent on investment on the right hand side. Nevertheless, the main reason to fix any *rate of interest* is to get data for the calculation of an optimisation strategy. Optimal strategy shows how to behave in the period from *start* to *end* of construction time or investment assets. The correct value of γ seems to be a more comprehensive question.

Nevertheless, as may be shown, there is no relation between strategy (structure of construction works) and robustness of interest rate (time factor) build into optimisation. For an *optimal strategy* it is *irrelevant* how considerable the value γ really is. This value only makes bigger the penalty if management does not keep to an optimal strategy.

In the technologies and organizational processes for industrial buildings, railways and road reconstruction, public utilities and housing developments there are *assembly procedures* that are very appropriate for the given purpose[3]. The investors of large investments and all public invested money may be spent more efficiently if an optimisation strategy can be calculated.

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[2] As in the 90´s from state owned enterprise and the state planning economy.

[3] Complicated research-, development-, innovation-projects are all very good aspects of these kinds of applications.

Months																									Total	Total	Total Q
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Q	Q´	Limit
Section A																									300		300
0	0	0	0	0	0	0	0	0	300																	30,000	
Segment A1																									100		100
0	0	0	0	0	0	0	0	0	100																	20,000	
Segment A2																									50		50
0	0	0	0	0	0	0	0	0	50																	7,143	
Segment A3																									40		40
0	0	0	0	0	0	0	0	0	40																	5,714	
										Section B															200		200
										0	0	0	0	200												0,000	
										Segment B1															70		70
										0	0	0	0	70												0,000	
										SegmentB2															40		40
										0	0	0	0	40												0,000	
															Section C										100		100
															0	0	0	0	0	0	0	0	0	100		0,000	
															Segment C1										60		60
															0	0	0	0	0	0	0	0	0	60		0,000	
															Segment C2										70		70
															0	0	0	0	0	0	0	0	0	70		0,000	
Section D																									250		250
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	250		0,000	
0	0	0	0	0	0	0	0	0	490	0	0	0	0	310	0	0	0	0	0	0	0	0	0	480	1280		
1,21	1,20	1,19	1,18	1,17	1,16	1,15	1,14	1,14	1,13	1,12	1,11	1,10	1,09	1,08	1,07	1,07	1,06	1,05	1,04	1,03	1,02	1,02	1,01	1,00	1280	max	1280
0	0	0	0	0	0	0	0	0	552	0	0	0	0	336	0	0	0	0	0	0	0	0	0	480	1367,623	1000	γ = 1,1

Fig. 3: Deadlines and costs for latest possible execution (without optimisation) – no speed limit.

A simple shift of production activities to the *latest* time limit is not the best solution (without optimisation). In Fig. 3. the production activities are optimised and carried (finished) out *at the latest possible moment* (however indicates only space available, not realistic situation). The final and most difficult opportunity for reducing the cost of the whole process of carrying out is the construction work through **optimisation of speed**. Optimisation brings major savings (see Table 1). In the given case, the deadlines and financial payments take into account *production speed* of individual production activities (jobs), taking technological considerations into account, including interest payments, for completing the construction. The optimum solution is in many ways surprising. See Fig. 4 and compare the results with the calculation table[4] in fig. 1a (or earliest possible practical execution) and Fig. 3 (latest possible execution, no speed limit). The total difference between the starting situation (Fig. 1a) and the solution in an empirical shift to the latest possible deadline is relatively low. Sophisticated changes, using optimisation, might lead in many cases to a radical drop in the total costs. Even if no profit could be achieved in practice, there is a range of possible managerial manipulation that could, if skilfully exploited, produce cost savings.

A more detailed analysis can show under what conditions production sources (production speed or cash flow to activities) can be increased.

[4] Original proposal of management

Table 1 Comparison of solutions

Actions total (in t. €)	**Earliest possible deadlines** - hypothetical production speed = 1000	**Latest possible deadlines** - hypothetical production speed = 1000	**Optimisation for speed 300**
Total costs (no IR calculated)	1280	1280	1280
Including bank loans (IR = 10%)	1488,903	1367,623	1370,852
Speed	1000	1000	300
Proportion, incl. IR in %	100%	91,85%	92,07%

Let us compare the structure of activities in Fig. 4 with the non-optimised solution in Fig. 1, and let us look at Table 1, where columns 2 to 4 give the main parameters.

1. duration times are changed for all production activities,
2. production speeds are changed in the course of execution for all production activities,
3. the total duration of the construction work is changed (or the proposal to create new time reserves to cover risks in connections with production speed),
4. the main production processes will be speeded up, the duration of the project will be shorter,
5. the average production speed of the construction work is the same as the original production speed,
6. a decrease in total costs to in comparison with the initial solution.

Other scenarios could also be presented. The main outcome of the whole task is an increase in **production speeds** and a **reduction of time margins** (floats). The overall effect is in essence a change in the organisation of project completion.

Most construction work is financed by credits. The contract is modified by regulations to the Commercial Code. This contract states that the creditor will provide funds up to the agreed amount to the benefit of the borrower. This contract requires the borrower to return the provided funds and to pay interest.

Months																									Total	Total	Total Q
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	Q	Q´	Limit
Section A																									300		300
0	0	0	0	0	0	0	0	116	184																	30,000	
Segment A1																									100		100
0	0	0	0	0	0	0	0	22,6	77,4																	20,000	
Segment A2																									50		50
0	0	0	0	0	0	0	0	25,6	24,4																	7,143	
Segment A3																									40		40
0	0	0	0	0	0	0	0	25,6	14,4																	5,714	
										Section B															200		200
										0	0	0	10	190												0,000	
										Segment B1															70		70
										0	0	0	0	70												0,000	
										Seg.B2															40		40
										0	0	0	0	40												0,000	
															Section C										100		100
															0	0	0	0	0	0	0	0	73,2	26,8		0,000	
															Segment C1										60		60
															0	0	0	0	0	0	0	0	0,99	59		0,000	
															Segment C2										70		70
															0	0	0	0	0	0	0	0	6,8	63,2		0,000	
Section D																									250		250
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	151		0,000	
0	0	0	0	0	0	0	0	190	300	0	0	0	10	300	0	0	0	0	0	0	0	0	180	300	1280		
1,21	1,20	1,19	1,18	1,17	1,16	1,15	1,14	1,14	1,13	1,12	1,11	1,10	1,09	1,08	1,07	1,07	1,06	1,05	1,04	1,03	1,02	1,02	1,01	1,00	1280	**max**	1280
0	0	0	0	0	0	0	0	216	338	0	0	0	11	325	0	0	0	0	0	0	0	0	181	300	**1370,852**	**300**	γ = 1,1

Fig. 4 Optimal solution or production speed 300 t. €/months of construction project.

5. A generalization of time dependent capacity expansion

The problem of optimal capacity expansion of construction work as a time dependent problem has been studied in recent years in many different applied contexts. Traditional capacity planning usually begins with a forecast of demand on the basis of organizational or technological needs. Planning and scheduling has for many years been the dominant approach in Central European management methodology. New approaches adopting a more productive methodology seem to be needed. Modern management of time dependent capacity expansion enables applications in *production planning*, *strategic planning*, *inventory control*, and *network design*. Applications to telecommunications have been published by Laguna [4].

The time dependent capacity problem consists of finding the combination of activities j (j = 1, 2, …, N) with price p_j and demand efficiency c_j , that should be employed in each time period t (t = 1, … ,T). The limitations are given by the total demand (capacity) D_t at a minimum cost.

Then, the problem becomes

$$min\sum_{t=1}^{T}\sum_{j=1}^{N} p_j \gamma^{t-1} x_{jt} \tag{7}$$

subject to

$$\sum_{t=1}^{T} \sum_{j=1}^{N} c_j x_{jt} \geq D_t \tag{8}$$

for all t where

$$x_{jt} \geq 0 \tag{9}$$

is production speed for all j and t. Further γ = 1+i enables the recalculation of production speed values on future value, by means of a discount factor (0 < i <1) for all x_{jt} for activities j in time t.

The structure of the production speed may be very variable. Table 1 shows a general example of this interpretation. Demand D_t may be structured not only as to t as a particular time period, but also to demand blocks related to different activities j and even to blocks of technologically or organizationally related activities.

Table 2 General scheme of a production structure

	t =1	t =2	t =3	…	t =T
Activity *1*	x_{11}	x_{12}	x_{13}	…	x_{1T}
Activity *2*	x_{21}	x_{22}	x_{23}	…	x_{2T}
	…	…	…	…	…
Activity *N*	x_{N1}	x_{N1}	x_{N1}	…	x_{N1}
	D_1	D_2	D_3		D_T

If the matrix of variables in time t, where t = (1, 2, 3, ..., T) is assigned for particular scenarios, where (s = 1, 2, …, S), say as z_{ts} , the problem becomes [4]

$$\min\ F(\mathbf{x}) = \sum_{t} \sum_{j} p_j \gamma^{t-1} x_{jt} + w\rho(\pi_s, z_{ts}) \tag{10}$$

subject to

$$\sum_{t} \sum_{j} c_j x_{jt} + z_{ts} \geq D_{ts} \qquad \forall\, t, s, \tag{11}$$

$$x_{jt} \in (0, 1, 2, ...) \qquad \forall\, j, t, \tag{12}$$

$$z_{ts} \geq 0 \qquad \forall\, t, s, \tag{13}$$

where w is the weighting factor and ρ is the function of negative demand consequences related to the unmet demand z_{jt} and probability π_s in the range of scenarios.
Demand D_{ts} will be presented with an uncertainty component z_{jt}, see (11). This represents an imaginary demand associated with the risk of shortage of capacity with a probability π_s related to scenario s at each period t. Function ρ may take many forms. It usually reflects the risk attitude of the decision maker. The risk may be associated with the probability of shortage of capacity, the risk of extra costs or the risk of lack of quality if the production speed exceeds certain limits. Further applications and interpretations are possible.

6. Model construction – further generalization

An interesting question is how far an optimal solution is dependent on production speed and what may be the optimal construction *duration* of an investment project. Let the production speed be seen as a given limit for construction of demands D_t .

$$\sum_{t=1}^{T} \sum_{j=1}^{N} c_j x_{jt} \geq D_t \tag{14}$$

The optimisation function remains in the shape given in the function (8). However the main constraint is given by maximum possible speed, that is a modification of the equation (14). Table 3 shows the optimisation result.

Table 3. Production speed and minimal costs for i = 0,10

Total Q´ max	**Optimal solution earliest**	**Optimal solution latest**
t. €	**t. €**	**t. €**
300	1 483,27	1 370,85
200	1 477,96	1 374,87
100	1 462,18	1 386,56
90	1 458,62	1 393,85
80	1 454,34	1 397,52
70	1 447,05	1 397,76
63	1 411,49	1 411,49

As Table 3 indicates there is a strong dependence between *production speed* and the costs of projects. Higher production speed means lower costs. More illustrative are data in Fig. 5. Total cost of projects grows in correlation with the rate of exploited production speed.
What is more interesting is the structure of activities. According to production speed, the time and cash flow structure of construction work changes.

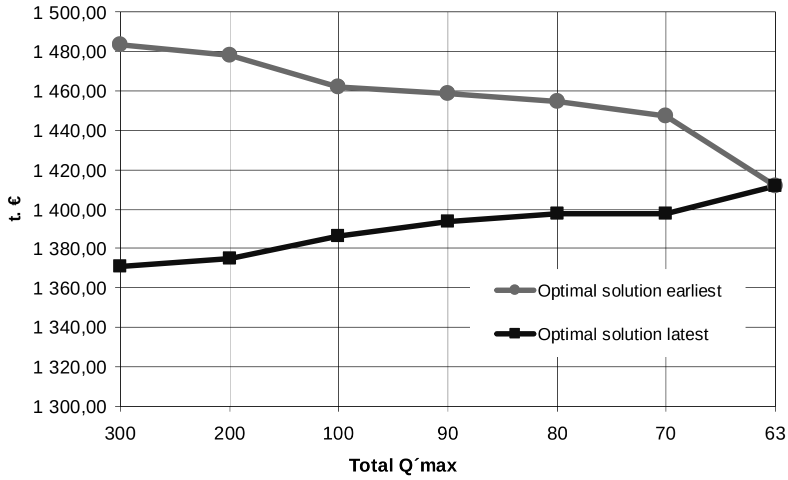

Fig. 5 Dependence of optimal solution and total Q´max.

It is interesting, that the structure of activities will not change if we increase economic pressure by means of interest rate γ^t. There are professional discussions about the level of interest rate that would be necessary or needed for the development of an economic calculation (in terms of efficiency and decision-making). In our case we are looking for an optimal duration and optimal cash flow schedule of construction work. The level of interest rate is irrelevant if only $\gamma > 0$.

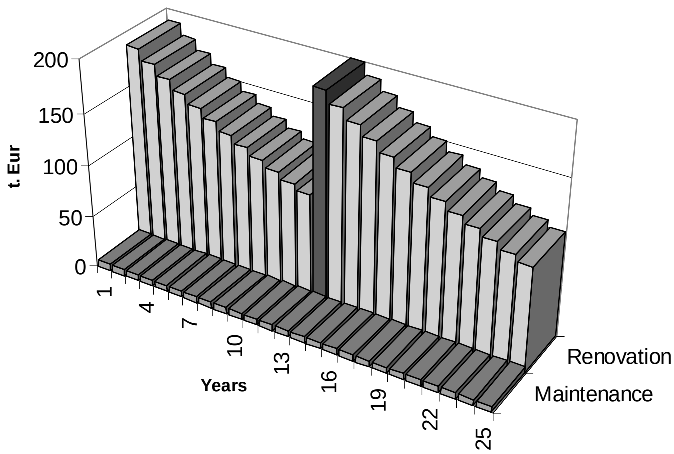

Fig. 6 LC of renovation and maintenance, construction decay speed (renovation costs as black histogram).

7. LC and non–linear optimisation

Similar as construction of the production cycle is possible to optimise maintenance and renovation cycles. The speed of *decay* and given limit of *standards* are the most influenced input data. These limits influence the optimal renovation cycle of construction elements and the prospect of future costs. In Fig. 6 and Fig. 7 there are results of optimisation. High speed of decay of implemented construction parts lead to high requirements on standards and to short renovation cycles. The low or high level of maintenance is influencing renovation cycles.

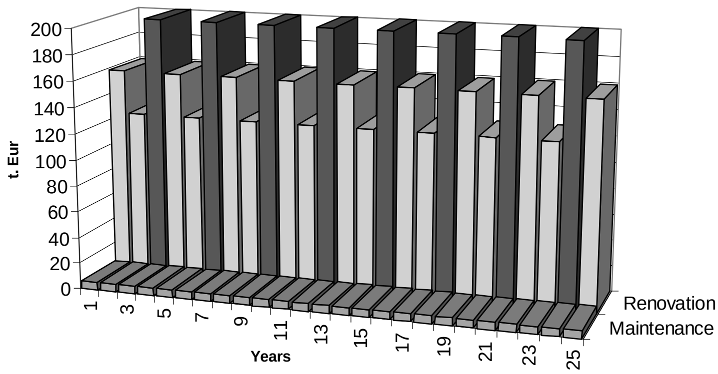

Fig. 7 LC of renovation and maintenance (high speed of decay).

8. Conclusion

The implementation of a technical project carried out in conditions of high production speeds and low time reserves requires changed technologies, organization and preparation of construction. In each specific case, a civil engineer needs to know the economic impacts (the capability of applicable calculations). The next important factor in the preparation and choice of management and organisation is the ability to calculate the risks inherent in the chosen technology [1],[2],[3]. It is obvious from the given illustrative example, which has the same features as the execution of a series of construction projects in recent years, that the myth of the importance of executing works in large volumes ahead of the deadlines has significant financial consequences. The interest rate applied here (10%) is not relevant for existing commercial conditions, but there is no ultimate dependence of structure and the corresponding IR.

It is very probable that wherever construction work has to be, or was, carried out at a loss or at a low profit, bad time management and cash flow scheduling play a significant role in the economic results.

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Modelling Expenses for Repair Works

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Abstract

On the territories of the former Soviet Union after World War 2 a number of standard-design panel buildings were constructed. In Estonia, construction of such buildings was terminated by the beginning of 1990s. As the quality of building and requirements for, most of all, keeping of warmth of that time differ greatly from those that are followed today, many owners of such buildings have started to repair and modernise the blocks of flats built at that time.

An interesting research topic in such a process is the model of how the decisions are made by the owners, how the expenses are estimated before the repair/construction process, and how the client (in most cases the flat owners' association) acts to organise the building process.

Keywords: budget, repair works, block of flats, priorities, renovation costs, Estonia, decision-making

1. Introduction

Flat owner's association is a non-profit association established by the owners of the flats to manage the legal shares of the buildings and plot of land which are the components of the apartment ownership, and to represent the shared interests of the members of the association.

The association has to act according to the valid laws, more important of which are the Apartment Associations Act and the Building Act. At the same time, there are the traditions, how to plan and carry out the processes in the association. As at the moment the inspection of how the legislation is followed is in many areas insufficient, the legislation can easily be evaded.

Lack of experience for most associations when planning the repair process makes the situation even worse. In addition, the prices of construction materials have practically reached the Western European level, while as the average salary is 3-5 times lower than in Great Britain, Germany, or our neighbouring country Finland. Due to that the associations are motivated to look for different tools and for legal or even illegal possibilities to minimise the expenditures for repair works.

As at the beginning of 1990ies the ownership relations to apartments changed totally – the formerly publicly owned flats were privatised – the new property owners appeared who have never ever acted as a property owner. Correspondingly, they lack experience and quite often even resources for this role to carry. According to the definition in Estonia, repair of the property includes a set of administrative and technical measures carried out during the lifetime of the property to preserve or/and to restore the situation where the property is suitable for purpose meeting the relevant requirements. (Liias, 2001)

In Estonia, during the period 1950-1990 mainly new flats were developed and minimal care was dedicated to maintenance and repair of the existing dwellings. This why, today the majority of these people who have now become the owners have the emerging necessity to start up reconstructing these flats. Especially the associations meet tremendous problems how to follow the interests of very different owners.

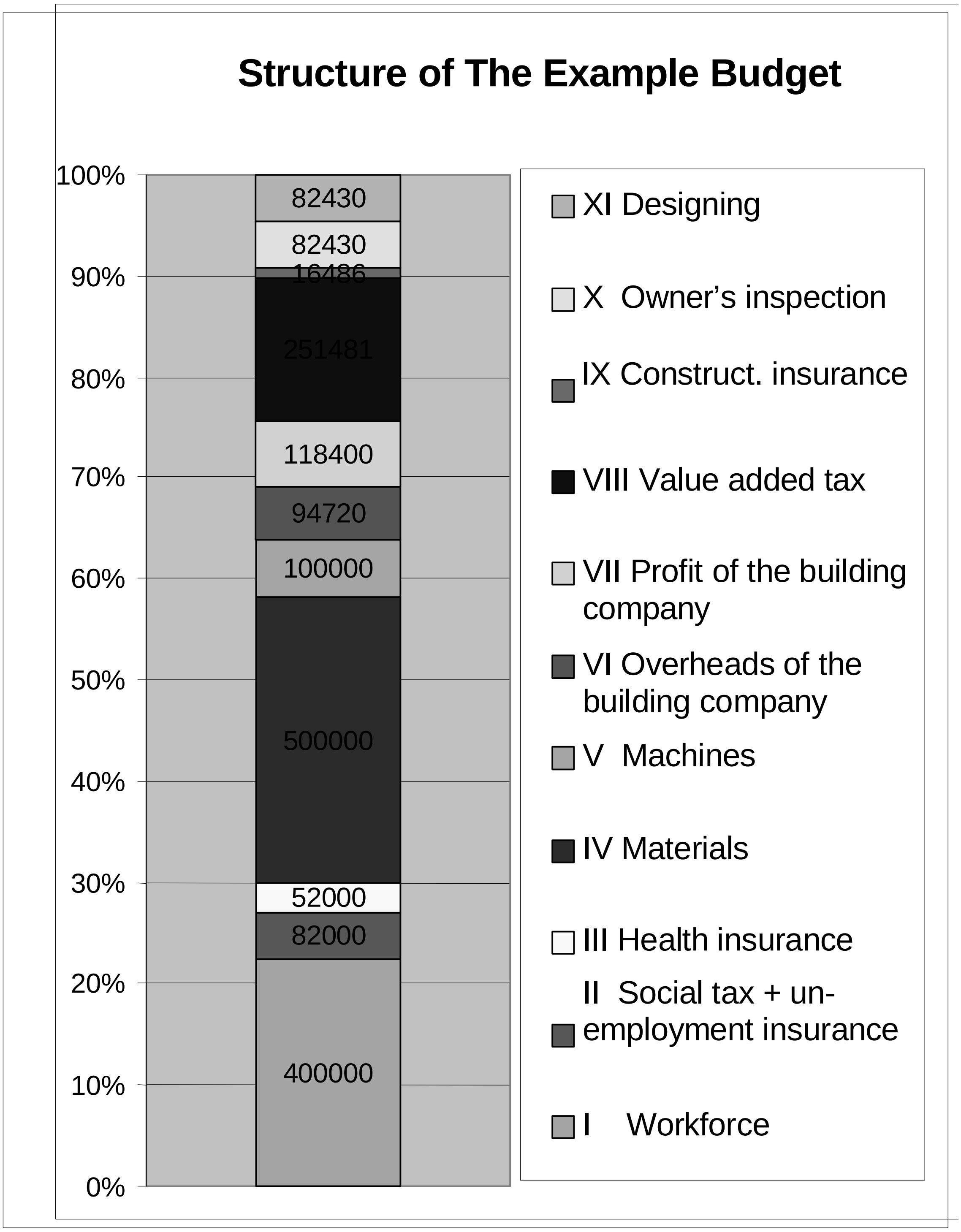
The problems highlighted in the current paper are related to the doctoral theses of the author of the paper. The theses are targeted to develop a complex model of expenditures for developing and maintaining the buildings.

Now the description of two different decision-making models is given to compare the logic of human thinking when planning repair works on shared ownership. There is the legally and professionally sound model, but there is also the model based on practice, which is quite widely spread in the homeowners' associations in Estonia. Construction costs are only a part of total costs that the contracting entity has to incur and account for [1]. In the current paper, attention is also paid to those aspects of expenses that come along for the owner or the client together with the repair works.

Table 1: Structure of Expenses in the Example Budget

WORKFORCE	**400000** 40% GROSS WAGES, INCLUDING INCOME TAX (26%), EMPLOYEE'S PART OF UNEMPLOYMENT INSURANCE (1%), PENSION INSURANCE (2%) AND HOLIDAY RESERVE (8.3%).
MATERIALS	**500000** 50% WITHOUT VAT (VALUE ADDED TAX) (18%)
MACHINES	**100000** 10%
TOTAL DIRECT COSTS	**1000000** 100%
TRANSPORT COSTS	**50000** 10% OF MATERIAL VALUE
SOCIAL TAX	**80000** 20% OF WORK FORCE VALUE
HEALTH INSURANCE	**52000** 13% OF WORK FORCE VALUE
UNEMPLOYMENT INSURANCE	**2000** 0,5% OF WORK FORCE VALUE
DIRECT COSTS+TRANSPORT +TAXES	**1184000**
OVERHEADS OF THE	**BUILDING COMPANY AND**
CONSTRUCTION SITE	**94720** 8%
PROFIT	**118400** 10%
NET BUDGET	**1397120**
VALUE ADDED TAX	**251481.60** 18% OF NET BUDGET
GROSS BUDGET	**1648601.60** 165% OF DIRECT COSTS

Table 1 portrays example budged and structure of expenses. Picture 1 clarifies structure of example budged.



Picture 1. Structure of repair works' expenses

2. The Priorities of a Flat Owners' Association with Little Experience in Organising Repair Works

2.1 Designing

In Estonia, design costs are, as a thumb rule, 3-10 % (Picture 1, XI) of the total expenses. Thus it is very tempting to save expenses in that amount. It is likely, that the understanding, which was popular for years that everything can and must be done by oneself, has its influence here.

2.2 Coordination and Applying for a Construction Permit

In addition to money, lot of time is spent on the planning process and as a rule, association representatives are engaged in co-ordinating and applying for a construction permit. There comes the possibility for further liabilities (which in most cases are not paid for) and with several intentions of repair works (e.g. closing in balconies, building additional storeys, boundary fences, etc) there is the possibility that necessary co-ordinations cannot be obtained and thus it would be better to circumvent the legislation, especially as it means saving expenses. People often try to avoid problems described above by taking advantage of gaps in legislation or insufficient inspection of laws and naturally, an important reason for this kind of behaviour is bureaucracy. Namely, even if there are little volumes of repair works to be done, the issuing process of the construction permit may take for months; according to the law it means that works cannot be started until the permit is actually issued.

2.3 Consultants

A consultant as a party in the construction process is a relatively new feature in Estonia, many associations have doubts concerning their competency and necessity. Obviously, often there is a consultant from the association or amongst the friends who is believed to give advice without any expenses. As we have stated, many associations carry out repair works without the design-phase and if the constructor does not have any serious problems during the repair works (in general, even if there are any, the contracting entity will not be informed), as a rule, the association will not feel the need to hire a consultant to get sound advise.

2.4 Overheads and Profit of the Construction Company

Profit and overheads form about 15 % in the repair works budget, which is a good possibility to save costs. Looking at economic results of Estonian construction firms in 2004 it appears that the profit of larger, general building companies is 4-7 %. For repair works, the profit per cent is probably slightly higher than for new construction, but no more than 10% (Picture 1, VII). Overheads of the company (Picture 1, VI) are connected both to organising specific repair works and to running of the firm as a whole – office administrative expenses, salaries of the employees, communications, transport, and other costs.

2.5 Choosing the Best Offer

At the flat owners' association meetings, many of the owners think that 'the cheapest is the best'. For the chairman of the association and for his advisors not acting according to this principle when choosing the company for repair works would mean long and thorough explanations, also suspicions of corruption.

2.6 Construction Inspection

In Estonia, construction inspection, especially owner's inspection is a relatively new notion. The situation here is similar to that of consultants – for the association, the limits of inspection responsibility and rights are vague and the system of payment is not clear either. It can be said that the construction inspection costs 3-10% of repair works budget (Picture 1; X). Actually, the problem with construction inspection is much wider than it first seems. Namely, often the two major parties in the repair process – association and the construction company – do not want to involve any inspection. The contractor is certainly afraid of stronger control over building process and the client of additional expenses to hire inspectors.

However, extra costs threaten the party who orders even if the inspector does his job well and, for example, orders the contractor to use more effective and thereby also more expensive construction technology or to replace certain materials with those that meet the requirements. As by this the whole repair work becomes more expensive, the contractor tries to get the missing sum of money from the person who orders referring to insufficient building design documentation and a need for extra works. But as mentioned before, an association often does not order design documentation or its quality level is very low, which means that good inspection causes very likely indirect additional expenses for the client.

2.7 Time Factor

Often the association tries to shorten the time-lag from creation of the idea until repair will be started and completed. When in the case of business projects it can be reasoned economically – the sooner the object is ready, the sooner it will earn profit – it is not often the case with associations. Time consumption is reduced quite often as the association has "woken up" too late and for example there is the need to finish fieldwork before the weather will be cold, or there is some pressure in the association to enjoy the results of the repair works as soon as possible. It is hard to give a specific financial value to this issue – it is difficult to estimate the satisfaction that the association members will get from the newly renovated stairway, it is also hard to evaluate the damage that comes from using a building design documentation of poor quality. Of course, there can be some exceptions. Insulating sidewalls of the block of flats has a direct impact on heating costs and by shortening repair process by a month during the heating period, one can count the financial gain. But in comparison with the cost of possible construction faults made in such a rush, the financial gain is insignificant.

2.8 Illegal Workforce

Using illegal workforce comes from the desire to save money from taxes. In Estonia, social security tax is 20% (Picture 1, II), health insurance 13% (Picture 1, III) and unemployment insurance 0.5% (Picture 1, II) of the salary that the construction company pays, and income tax is 24%, so the possible financial gain is quite reasonable. Although every project is different, the money paid to the workforce for the reparations is at least 40% of direct costs (Picture 1, I). Other direct expenses – the cost of materials and machines – correspondingly account for 50% (Picture 1, IV) and 10% (Picture 1, V) in case of this example. Presuming that 75% of the total budget is composed by direct costs (expenses on materials, machines, tools and workforce), then when using illegal workforce the association would benefit by 15-20% of the total cost of the repair works (from the taxes mentioned above) in comparison to an association that avoids using illegal workforce. In addition, the association can save 18% value added tax (Picture 1, VIII) if they do not enter into an officially signed contract with the construction company.

There are a number of other problems that causes this kind of behaviour. Here are only a few keywords for this: quality of work, safety, social guarantees, and the rights of the client.

Contractual relations between the association and workers are not the only issue here. There is usually also an intermediary, the construction company. In the point of view of the association, entering into a contract with the construction company is difficult, time-consuming, and requires expensive lawyer’s consultations. A contract makes it also more difficult to avoid the legislation that would reduce the budget.

2.9 Safety at Work

Although the actual danger of accidents in construction sector is one of the biggest, it is still hoped that nothing will happen, and even if it will, the construction company will remain fully responsible then. Building insurance is often an unknown term for the clients amongst the associations and even if he has heard about it, he tries to avoid it to save costs. As a rule, the gain is 0.5-1% (Picture 1, IX) of the total cost of the works.

2.10 Competitive Bidding

As already stated, in many of the cases the lowest price is a trait of the best offer for the association. To meet this requirement, many price enquiries are made because in comparison, the best candidate for the job should be easy to choose. Sometimes, the offer of one firm is sent to another, asking them to lower their price accordingly.

There is also another widespread way of behaviour, which is used if competitive bidding is too commanding (knowledge, time) or a well-known person (often not even a specialist) has recommended a company. This process is clearly different from negotiations, as in this case the details of the process will not be specified, it is important to start the repair works as soon as possible.

3. Model of Activities of an Experienced Client

3.1 Concept of Repair Works

The idea of repairing a house has to be discussed in the association to find out if the idea itself is acceptable for association members, financial possibilities and time schedule have to be evaluated, etc.

The members of the association enter the status of a client by deciding to start repair works. This brings along rights, duties and responsibility. Actual situation in the flat owner's associations in Estonian is that the members are very different both in their ways of thinking, but also as to their economic capability. Starting the process of organising repair works, the association has to make sure that people are ready and the aims are clear. The general, plan of action and the people running the project have to be specified, etc. But attention should also be paid to financial questions.

3.2 Choosing a Designer for Repair Works (Negotiations)

Just like with construction companies, there is also quite a tense competition among the designers, but knowing the specific character of design work, the budgets of compiling building design documentation with equal quality cannot differ very much. Difference usually comes if necessary elements of the building design documentation (which as a rule means the quality) differ.

Paragraph 18 of Estonian Building Act says the following about the building design documentation:

Building design documentation shall be such that it is possible:

1) to build on the basis thereof;

2) to use and maintain the construction works;

3) to inspect the conformity of building with the building design documentation;

4) to inspect the conformity of the construction works with the requirements established by legislation. [3]

An experienced client does not choose the cheapest designer but the designer who, with his skills and work experience, guarantees the preparation of technical documentation on such a level that it guarantees:

1. getting all necessary co-ordination, safety of the solution during period of use
2. the possibility of drawing a reliable budget
3. execution of technically correct solutions by the constructor
4. getting a building permit and an authorisation of use for the building
5. meeting the contracting person's requirements, at the same time implementing current procedures.

As the cost for designing forms about 5-10% of total expenses, it is assumed that the expenditures to a low quality design-solution may be half the price of a high quality solution, the client can save only up to 5% of the total costs. This is the risk that an experienced client would not take.

3.3 Association's Requirements on the Final Result

There are the three main strategies when organising repair of immovable property [2]:

1. best result
2. minimal cost
3. balancing revenues and expenditures

It is common knowledge that in an early stage of designing a huge part of future costs are determined – designer determines the main structures and materials that he will use. At the same time, it is in consistency with the client's wishes and requirements and current standards. In this stage, every client influences directly or indirectly the design budget. This is why it is very important that the association has discussed the problems and specified its needs and requirements. As an association may not have professional knowledge to analyse the problem from a technical or financial point of view, consultants' assistance should be used.

3.4 Applying for Consents and Building Permit from Corresponding Institutions and Association Members

In the previous chapter it was said that often an inexperienced association has the priority to start repair works as quickly as possible after the idea has come up. An experienced client can reduce the time-lag between having the idea and beginning repair works by starting co-operation with the designer. The process for applying consents takes place both in the association (getting the approval from the association members to both technical solutions as well as to the financial decisions), but also in the public institutions. The latter process is lead, in Estonia, mostly by the designer. The co-operation of the activities by the designer and the representative of the association will be still necessary – they both need to be present when obtaining the consents. From the viewpoint of expenses it is most necessary to have the consent from all the relevant parties before starting actual construction work, otherwise there might be many problems afterwards.

Repair works without necessary consent are illegal – obtaining the consent is related to inevitable costs by the client. But if the public institutions for inspection find the illegal changes done already cannot be accepted legally, the association has to restore the old situation and this bring along even bigger costs.

3.5 Draft Design and Cost-Estimate

During the initial phase of the project a draft plan has to be ordered from the designer, which is the basis for the first cost-estimate.

According to Estonian Building Act design-works are divided into three major stages – pre-design, design documentation, and shop-drawings [3]. It is necessary to go through preliminary design – making a draft plan and reflecting the contracting person's requirements and wishes in it – before beginning the actual designing. Based on the preliminary design, a cost-estimate is compiled and information about future expenses can be gathered from analogous ready buildings.

3.6 Negotiations with Banks and Members of Association

Knowing the estimated sum for the repair works, required finances has to be supplied. This process includes planning of future cash-flow for the association as well as establishing a contact with a credit providing institution and working out the best financing scheme. If the sum of money in the cost-estimate can be covered from the own sources of the association and/or from the loan, the designer must be assigned to continue working with the project.

3.7 Budget According to the Main Design Documentation

For the second time, now more exactly, the total cost of the building can be estimated when the principle design solution has been worked out, i.e. the solution in construction and design of the building, the main quantities of works and necessary equipment are known. Then the owner should ask for the budget as well in addition to the technical drawings provided. To determine the cost of construction now aggregated price norms per structural elements may be used.

3.8 Budget for Shop-Drawings

For the third time, the association representative can ask the designer to count the costs of the whole design when there are shop-drawings available. After the drawings are completed, building cost can be determined at the most detailed level, i.e. on the level of the unit prices.

3.9 Activities of the Client When the Design Is Complete

Together with the designer, it is necessary formalise the consents and a building permit will be issued to the association. The procurement scheme will be selected and the contractor will propose the construction cost for the project. When the most favourable contractor is chosen, the contract is signed with him, but also the contracts with consultants and building inspection.

4. Conclusions

As can be seen, the way decisions are made and costs estimated before the repair or construction process and how the client [4] acts to organise building process, has an important influence on the whole building process as well as the structure of expenses. The following points often depict the situation that exists in Estonia in the flat owners' associations when a repair-project is initiated:

§ It is not clear, which decisions and activities influence the budget of repair works seriously and which not so much;

§ The generic model of organising repair is based on the fact that the best solution is no always guaranteed for the client, and the legislation is not followed as for management of the repair-works. Search for the best solution is directly connected to the budget, its different stages and principles of preparation, also designing and the activity of building consultants,

§ It can be followed that state taxes and overheads and revenue of the construction company form a big share from the total expenses of repair works. Associations, however, do not exactly know what they get for that money. This causes problems with contracts, which in turn result in problems with rights, duties and responsibility, etc.

In connection with various social-economic and legal problems, but also with traditions and widespread misunderstandings, the associations tend use a model that minimises costs by avoiding legal requirements. A more thorough analyses which is planned for the Doctoral thesis, is to show by specific activities which are the impacts of using one or the other activity complex and which is the financial result of such actions.

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User Values of Intelligent Buildings

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Abstract

Intelligent buildings can be understood as a wider concept than that of automated buildings which benefit from information and communication technology and can be understood as an expression of building logic, a form of building intelligence. However, first intelligent buildings are built according to intelligent building concepts following the broke down of technical and economical statements of them. Empirical data of intelligent buildings was gathered from twelve office buildings built in Finland in the end of 1980's till the middle of the 1990's. The end-user response and functionality of the buildings and cost-effective life-cycle calculations have been in focus in judging the quality of them. Costs and gained profits of intelligent features are discussed based on alternative frameworks for cost-effective life-cycle and their influence on office workers working efficiency which together form the paradigm of efficacy of intelligent office buildings.

Keywords: intelligent buildings, life-cost cycle, knowledge management, information era, information and communication technology, intelligence of buildings, automated buildings, integrated buildings, building logic, cost-effective, efficacy, spatiality

1. Introduction

1.1 Intelligent Building Concepts and Intelligence of Buildings

Buildings have been built intelligently through ages, but the information era has introduced the concept of intelligent buildings in a new context together with intelligent production and products (

Figure 1.). New requirements have been set on the use of buildings according to knowledge work, new industrial manufacturing principles and advanced housing and living styles. Without touching the phenomenon of intelligence of buildings in depth it is only pointed out in this context that during the information age building intelligently has become more consciously understood, in other words the tacit knowledge of building has transformed into explicit one (Figure 2., cf. also [0], [0], [0], [0]).

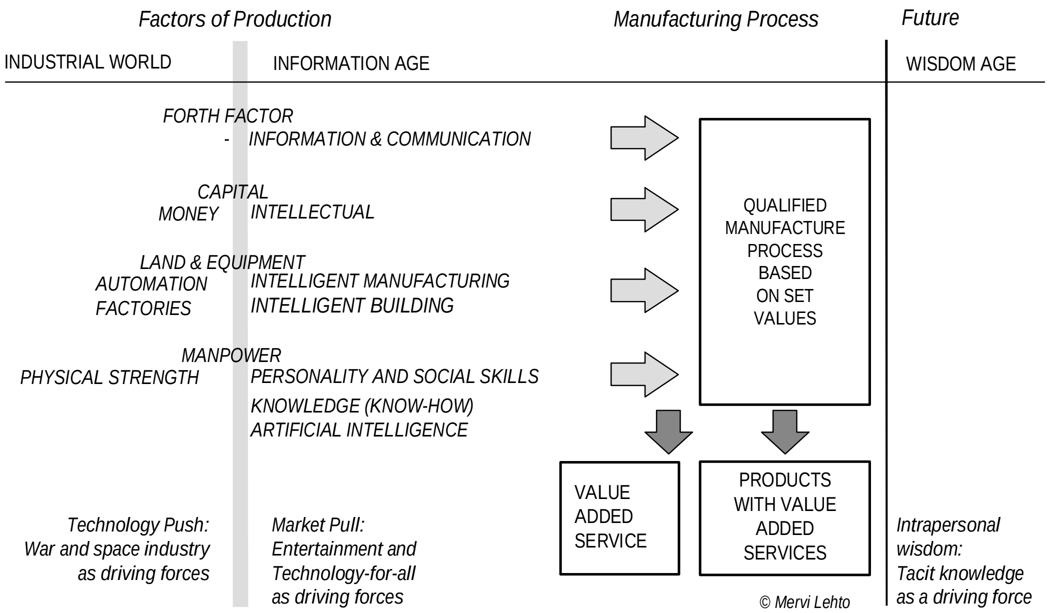

Figure 1. Intelligent Buildings as part of the process of manufacturing of products with value added services by knowledge of quality engineering, awareness of company values and the fourth factor of production, e.g. information[0].

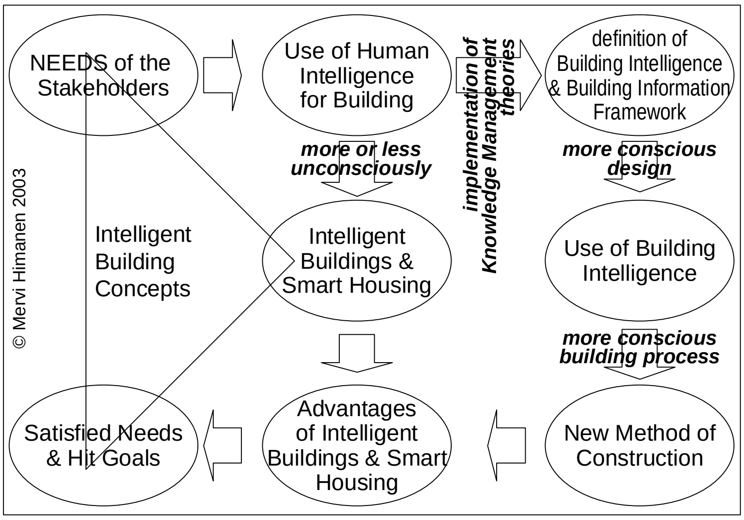

Figure 2. Building intelligent buildings [0].

Intelligent building concepts are not definitions of intelligent buildings but they describe the features of intelligent buildings according to which they have been built (Figure 2.). Several variations of definitions of intelligent buildings exist. Some of them highlight the utilisation of information and communication technology (ICT) in construction. They are rather definitions of integrated or automated buildings. The intelligence of buildings is a holistic, inter-disciplinary concept [0], [0], [0], [0], [0].

Salokangas [0] has introduced the intelligent building as a system of activities highlighting the importance of various stakeholders and their interests concerning the functionality of the building. He has referred to the Japanese ideas of the creative building, but again focusing on communication, networking and new media [0], which refers rather to the integrated than intelligent buildings. Responsive building is a name for the beloved child. Later, transdisciplinary essence of intelligent buildings is described by Clements-Croome [0] and the five forms of buildings intelligence[1] by Himanen [0]. In this article, the cost-effectiveness of two forms of building intelligence logic and spatiality will be discussed.

Realisation of an intelligent building requires participation of the representatives from many disciplines. Building developers and designers, building automation experts as well as real estate and facilities managers, work in close co-operation with specialists in ICT, telecommunications and artificial intelligence. Organisational and psychological aspects co-operate with physical working environment for healthy buildings. Medical doctors and social scientists are drawn into

[1] 1. Building-connectivity (speaking and speech recognition including music and linguistics; user-connectivity and control: either personal or automatic or defined by the organisation in concern); 2. Building self-recognition (building knows the state it is in; a kind of consciousness); 3. Spatiality (a more conscious understanding of the spatial expression of the architecture, structures, interior design); 4. Building kinaesthetic (a sense of change, active structures, moveable structures, furniture and equipment, adjustable technology or building services), and 5. Building logic (embedded sensors to monitor the occupants' daily activities, combinativity)

building design. While knowledge of prosperity of a village, urban area or city is understood to be dependent not only on the number of workplaces but the quality of housing and municipal services providing good living conditions for top workers. Co-operation with urban planners and municipal workers is brought into play. Intelligent space is advanced up to intelligent neighbourhood.

1.2 Cost-effectiveness of Intelligent Buildings

Buildings are no longer kept as necessary costly shelters but rather as resources for profitable businesses. They help in living independently and cosy. Technological advancement, cost-effectiveness and stakeholder orientation are important factors of the intelligent building concepts according to which first intelligent buildings were built. Despite, ICT has been employed profitable in many fields entertainment industry has been named as a driving force of the ICT industry. Intelligent building is the construction industries share of the wider change of economy from industrial age to information era. The vision of the next generation ICT is progressing towards a content oriented communication industry and highlights the importance of the end-user in the research and technical development (RTD) work in the ICT in construction industries.

End-user empowerment can be named as next driving force in ICT business, and also in construction and real estate business as well as in intelligent buildings. Understanding the needs of occupants is paramount in today's real and facilities management (FM) sectors. Understanding market pull is now as important as the technology push approach was earlier. Product providers are taking care of the interests of various stakeholders at the same time. Design-for-all[2] and technology-for-all[3] concepts help in taking different needs of the stakeholders into account. Despite the needs of customers and end-users have been important in the development of intelligent building concepts [0], [0], the development has approached from the implementation of ICT and building automation representing the technology-push-type starting point for the RTD [0]. The more the ICT hardware industry has been growing, the more possibilities for equipment integration have become available.

Performance is a factor of the building feasibility. The four e's of performance are economy, efficiency, effectiveness and efficacy [0], [0] (**Error! Reference source not found.**.). Economy means doing things for low cost. Efficiency and effectiveness take into account the outcome of the input, instead of only minimising the input. Efficiency is doing things right, i.e. using resources well. Effectiveness means doing right things it is, taking into account the market demand,

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[2] Design-for-all design principles have been introduced to be able to approach the R&D work of technology according to different customer needs and at the same time keeping the concepts of cost-effective mass production in function.

[3] Technology-for-all is a concept of how to manage the education of ICT and encourage people to learn it.

satisfying the market in qualities. Efficacy means the relevance of the outcome, both qualitative and quantitative market saturation for successful business.

Common factors of the intelligent building concepts are [0]:

§ Needs of the occupants are dominant for the performance of buildings; emphasis is put on efficacy, while intelligent buildings provide the stakeholders with an effective and productive environment in order to allow them the possibility to maximum performance in achieving their business objectives.

§ The performance is gained in a cost-effective manner with minimum life-time costs. Despite of lowering costs, the buildings must be convenient and functional, the management of resources efficient and sustainability should be respected.

§ The performance needs will be met by integrating the best available concepts, materials, systems and technologies, architecture and structures, which match the stakeholders interests or needs

§ The performance can be implemented also with long-term flexibility in utilisation of space and adaptive and movable space elements and equipment, with comfort, convenience and amenities, service-orientation and user-friendliness of systems, safety and security, with guaranteeing working efficiency, image of high technology, taking into account local culture, construction process and structure, marketability, information intensity of systems, interaction of building and businesses taken place in it, ability of promoting health (therapeutic), reliability (stable and accurate), and productivity (profitability) at correctness of basic technical solutions.

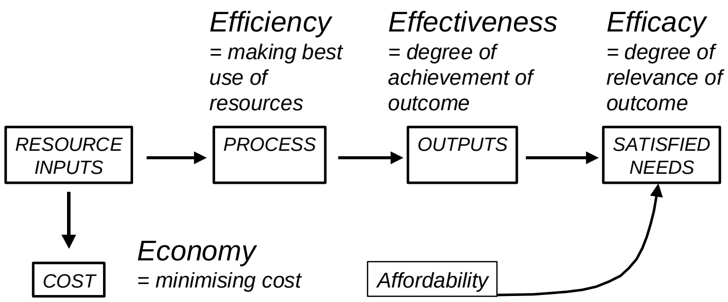

Figure 3.The four E's of performance [0].

Salokangas [0] pointed out the beneficial factors of intelligent buildings as: work performance, services and products will be better than in conventional buildings, activities can be carried out faster and more efficiently than before and the total costs of manufacturing services or products decrease since the investments in better building and more efficient equipment are compensated by savings in labour costs. Due to efficacy of the building in intelligent offices people get easily brilliant ideas, in intelligent schools pupils and students learn best, in intelligent hospitals people are cured and become better comfortably and permanently, etc.

After careful speculations and calculations of the shares of activity and investment costs of an office building Salokangas [0] ended up to the share of 90 per cent of activity costs and only 4 per cent of investment costs. He noted that additional investments on intelligence will increase the efficiency of the activities. Then additional investment of 20 per cent of the total buildings costs on intelligence will be paid back in three years.

2. Objectives

When intelligent buildings are approached from a holistic point of view usability of buildings follows from the understanding of human needs for space and for other building properties as well as the interplay between various aspects. A proposal for calculating the life-cycle cost-effects of intelligent features will be done according to the expectations of theories of buildings economy and empirical findings after intelligent office buildings have studied keeping office workers work performance and the goals of intelligent buildings in focus.

3. Methods

Approaches to feasibility of intelligent buildings are based on theories of economics of intelligent buildings by Salokangas [0], [0] and those of life-cycle values and calculations by Pulakka [0] in addition to empirical data collected in some examples of intelligent office buildings.

Life-cycle costs meaning total cost over a technical, economic or functional life-cycle, or whole-life costs which are total costs over the whole life of product or facility, building or building component are usually caused by acquisition, use, maintenance, breakings, renewal and environmental needs for a building, a system or a product (Table 1.). The same classification is applied within whole lifetime of facility − also in case of renovation and individual acquisitions. Present value calculations are the primary method for life-cycle costing. Present value includes all costs occurring within a chosen period of time discounted to a current cost level using a relevant discount rate. Annual costing is a fair method for cash flow analysis.

Table 1. Classification of life-cycle costs.

Type of life-cycle cost	Description
Acquisition cost	Building, investment, capital cost
Operating cost	Continual cost caused by the use of building including energy, water, waste, cleaning etc
Maintenance cost	Time-planned maintenance and renewing of components
Modification cost	Cost of spatial modifications
Development cost	Development of building or systems

Risk cost	Unexpected cost caused by moisture, fire, storms, breakings of systems etc.
Environmental costs.	Possible needs for soil refreshment and sheltering, use of raw material, cost of demolition and recycling etc.

Life-cycle economical comparisons should be focused on life-cycle characteristics of real importance (Table 1.). The importance of intelligent building features was tested by empirical data gathered in 1995−1997 by the end-user evaluation study; the Intelligent Buildings Survey (the IBs Survey). The comparisons considered such profitable factors as net savings, internal interest rates of return or pay back periods, as well as possible changes of market-values of buildings. The comparisons of economies between intelligent and traditional buildings are based on a cycle of 20 years and a funding period of 20 years with the interest rate of return being 5 per cent.

The IBs Survey was carried out in twelve office buildings in the Helsinki metropolitan area right after the first boom of construction of intelligent buildings was over, in 1993−1997 in Finland. 534 office workers were interviewed by a questionnaire of 417 parameters. End-user response measured the quality of intelligent building features and their effect to the working efficiency.

4. Results

The IBs Survey proved the productivity of office workers most dependent on the management of the space, on three organisational issues listed next below, and on three qualities of the physical environment:

§ Facilities management; especially the possibility to influence the design of ones' workspace (and workplace planning) and the availability of information of the building properties and how to use them.

§ Hierarchy of the working organisations of the occupant companies

§ Gender of the workers, but not other demographic parameters[4]

§ Stakeholders' roles and activities[5], occupancy and time spent in and out of office

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[4] Other not so important demographic parameters were: age, education, salary, attitudes towards supervisors, work satisfaction.

[5] Stakeholders are: occupants, visiters, occupant companies, real estate developers and providers, building managers, service and facilities management personnel, designers, building purchasers and speculators, building owners, the contractor, authorities, urban planners and community developers, local and global communities.

§ Workspace properties; especially the size of personal work space, indoor air temperature and flexibility

§ The number and quality of office automation tools and building properties

Such phenomena of knowledge workplace design as tools and space arrangements for intellectual capital or knowledge management and their influence on the efficacy of intelligent buildings as in the role of a knowledge workplace, if at all, were not studied.

4.1 Building Logic of Intelligent Building Features

Effective office working tools and good indoor air quality was important for the office workers and their working efficiency. Overheat was an obvious problem even in the intelligent Finnish office buildings in the 1990's. That was the case often because of the heat loss from the ICT tools being about 1.200 kWh/a, and costing 100 € per personal workspace (in 1997) while it could have been only one third of it if the equipment should have been shut down when not in use. If energy-effective tools (e.g. those of high rated by Energy Star classification) using energy only half of the previous mentioned were used and the deduction of need of cooling energy taken into count the saving potential of energy consumption could be almost 200 € per personal workspace.

The cost calculations and speculations of the intelligent ICT in office are based on the extra costs caused by the installations of intelligent building features and their positive or negative influence on the time spending and management, need of meetings and supportive services as well as on customer relations and on work satisfaction (

The adaptability and flexibility of the ICT working tools and furniture in offices was evaluated by all office workers as good for the productivity of work. Making flexibility available is cost-effective if need of changing spaces occurs every third to fourth year. This was the case in the offices studied by the IBs Survey.

Conference calls were not frequently used although the service is available by most interoffice telephone systems. Videoconferencing is a demand driven intelligent service. It is worth of time and money to draw a realistic profitability analysis of the investment and running costs as well as the return of it, with tele-operators. In this context only an example of it is given (Error! **Reference source not found..).** Videoconferencing technology can be cost-effective provided that it is used frequently and it can save at least 50 travelling days annually.

Table 2).

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Table 2. The Life-Cycle values of the intelligent buildings and their investment and annual costs, influence on office work productivity.

Intelligent Feature	**Cost / € (in 1997)**	**Experienced productivity[1]**	**Premiss for cost-effectiveness**
Routings in the assembly floor and other technology for adaptability and flexibility	About 5 per cent of total building costs per gross floor area 40 ... 50 €/ m^2	XXX	Need to change the spatial office arrangement at least in 3 to 4 years' intervals
Communication technology for auditorium and meeting rooms	Total cost of 1700 … 5000 €	X	Location of marketing or educative operations in-house
Videoconferencing	Annual cost of over 16700 … 2500 €	X/−	Constant need for fixed image connection
Access control and working time monitoring	Annual cost of 4200 … 1000 €	X/−	Smart card with additional operative options to controls

[1] Resulted from the end-user evaluation of the IBs Survey as follows: XXX ≡ significant influence, X ≡ clear influence and X/− ≡ flexible influences, which are more often experienced positive on the behalf of the company than on behalf of own work.

[6] The IBs Survey studied moving of furniture and walls, plug electrical devices, changing the place of phone or phone number, getting an access of computer to networks after moving, organising things and papers.

Table 3. A profitable analysis of provision for videoconferencing in 1997.

SAVINGS	€	COSTS	€
Per participant		Investment and rent	1680 … 3350
Work	335 … 840	Operation	4200 … 6730
Accommodation	500 … 840	Altogether	5000 … 8400
Travel	840 … 1680		
Altogether	1680 … 3350		
Per 3 … 5 participants	8410 … 1680		
Per arrangement costs	1680 … 3350		
Altogether	10.000 … 20.000		

Communication technology for meeting rooms and auditoriums was not considered very profitable, although it was found that they were evaluated to be more effective in buildings where they were available in-house. Access control is a most unfavourable intelligent building feature after the office workers' opinion. It might become better accepted if more positive options than controls could be added to it to serve the workers.

Although, the work satisfaction might become better a necessary precondition for the cost savings of intelligent building technology are the possibility to gain the established production with less work force and overtime work. On the other hand, some individual workers might even double their work load by using latest office automation technology. Any of the intelligent features studied by the IBs Survey cannot be proved to be unprofitable; function costs are reduced and cost-effectiveness gained best by technology for flexibility, by communication networks, intelligent telephone systems and smart access card for multiple purposes.

4.2 Spatiality − a Form of Intelligence

The costs of the additional shared spaces in the intelligent buildings were calculated to be 15−30 per cent of the construction investment and life-cycle costs (Table 4.). Salokangas came to the conclusion of 20 per cent after a study of one case adding all intelligent features − spatial and technical − together while Pulakka estimates them to be over 30 per cent of total building costs. There are several ways of building cost-effectively and intelligently.

The office workers evaluated the meaning of the in-house customer spaces and restaurants very important for their working performance. The payback period of the representative, extended lobby space ends up to less than five years. If the customer contacts are constant, the cost savings of having the meetings and product demonstrations in-house can be calculated as follows:

§ Potential annual savings in travel time if the customers are interested in coming to the provider's premises will be 0.5 million € if 200 hours per year are saved per 25 persons with hourly cost of 100 €.

§ A day's training event for 200 people calculated without the work costs will save altogether 10.000 € summarised from 5000 € from space rents, 2500 € from food service and 2500 € from other costs.

The most favourable personal workspace is a spacious private room. The rating the shared workrooms − especially those shared by two workers − as unpleasant is not only the opinion of office workers. Also the number of symptoms indicating health condition increases in shared rooms. On the other hand, it was found that some working groups were favouring open office arrangement which is spaciously effective solution and the construction costs of a personal working space there is one third less than that in room offices. If an expert will provide the occupant company with an annual value of 0.1 million € and the personal work space costs 0.001 € per year, it is obvious that there is no ground for extreme space savings while it leads to dissatisfaction and symptoms which might also mean discomfort and low work motivation.

Table 4.The construction costs of the shared spaces in the intelligent office buildings

Shared space	**Costs / € (in 1997)**	**Floor area used in calculation / m^2**	**Experienced productivity[1]**
Meeting rooms	50 … 100	50	XX
Show rooms	100 … 250	60 … 100	XX
Canteens and restaurants	50 … 100	50 … 400	X
Exercise and sport facilities	100 … 250	~ 100	X/−
Rest rooms and social spaces	35 … 50	50	X/−

[1] Resulted from the end-user evaluation of the IBs Survey as follows: XXX ≡ significant influence, X ≡ clear influence and X/− ≡ flexible influences, which are more often experienced positive on the behalf of the company than on behalf of own work.

4.3 Comparison between Summaries of Costs

Relevance of the building to the occupant weather it is an occupant company, a worker or a resident, e.g. efficacy of intelligent buildings is a sum up of cost-effectiveness of intelligent building subsystems. Economy is not the dominant feature in the purchasing of the intelligent buildings. However, in the case of reference buildings the price or the rent was second important factor in judging weather to move in or not, while it was sixth important in the case of intelligent offices after the IBs Survey [0]. The relevance of a house depends on the satisfaction of the client or the end-users which was taken into account qualitatively while the cost-effectiveness in question of twelve office buildings was studied during the IBs Survey.

The cost-effectiveness of an intelligent building compared with a traditional building is based on calculations and the end-user feedback of the influence of technology available on working performance by the IBs Survey. The example of a facility describes acquisition and life-cycle costs on property level and comparison of life-cycle cost-effectiveness within the chosen period (Table 5.). Calculations are made by a cycle of 20 years, a funding period of 20 years and the interest rate of return being 5 per cent. Thus the acquisition cost of an intelligent building is 30...40 per cent higher than that of a reference building. However, profitability is remarkably better because of potential for good incomes and permanency of market value. The impact of life-cycle-costing of an organization is proportional to how many significant life-cycle characteristics are set as demanding.

The discount of costs to current value was calculated by multiplying the annual average cash flow with the years of the length of chosen period. Accordingly, the current value is the average cash flow divided by the length of chosen period. The financing costs of purchases have been estimated. The purchasing costs are the same as the sum which the client has paid, while the other options are as shown in Table 1.

Profit potential (PP) is based on the average expected profit during the period by current price level (without calculating increase in cost level) while the profit value (PV) is the difference between profit potential and life-cycle costs (LCC). Life-cycle cost-effectiveness is dependent also on the market value (MV) after the period while the purchase is expected to be paid back during the period. Total life-cycle profit during the whole period is got by summing up the profit value and market value. Return of capital during the period is the ratio of life-cycle profit and market value. Calculation realise the cost of finance which is an important factor of life-cycle costs. Sensitivity analysis includes in addition to the presumable progress the pessimistic and optimistic growth.

Table 5. Acquisition cost, life-cycle cost and profitability of typical and intelligent office buildings (revised from the cost level of 1997).

Cause of cost	**Traditional Office building present value € per gross floor area m^2**	**Intelligent Office building present value € per gross floor area m^2**	**Traditional Office building annual cash flow € per gross floor area m^2**	**Intelligent Office building annual cash flow € per gross floor area m^2**
Acquisition (Aq)	1 620	2 190	81	110
Funding	970	1 390	49	69
Facility administration	100	140	5	7
- taxes	40	60	2	3
- insurances	25	40	1	2
- other administration	35	40	2	2
Operating				
- heating	100	60	5	3
- electricity	160	180	8	9
- cleaning	80	100	4	5
- other operating costs	80	145	4	7
Maintenance	300	400	15	20
- service actions	180	220	9	12
- renovations	120	180	6	9
Modification of spaces	500	60	25	3
Risk factors	60	100	3	5

Environmental factors	60	40	3	2
Life-Cycle Cost(LCC)	**4 030**	**4 805**	**202**	**240**
Life-Cycle Income (LCI)	**4 100**	**5 700**	**205**	**270**
Profit Value (PV = LCI – LCC)	**+70**	**+895**	**+3**	**+30**
Market Value (MV)	**1 300**	**2 000**		
Life-Cycle Profit (LCP = PV + MV)	**+1 370**	**+2 895**		
Profit Rate (PR = LCP/Aq) x 100/t	**4,2 %/y**	**6,6 %/y**		

The comparison of the intelligent and traditional office building shows:

- Rents of the intelligent offices have been 10 … 100 per cent higher, being lowest in the cities and highest in the areas where the supply exceeds the demand, in summary, the expected rent incomes have been as expected also during the economical regression of 1990's in Finland

- Benefits gained from less travelling or office costs have not realised but on the other hand, it has not been proven how much at the same time business opportunities have grown and what is the return got from it, in other words if savings are invisible due to the increase in business

- Decrease in value of the office buildings is 20 per cent in ten years but with well-managed intelligent office building it could be only 5 … 10 per cent

- In the 1990's the construction costs of an intelligent office could be 50 per cent higher because costs of structures were 25 per cent higher and electrical installations cost two to three times more

- Management and maintenance costs remain normal in the intelligent buildings except those of electrical installations which are double.

In the 1980's a cost problem was the voluminous ICT equipment, which preserved floors in tele-operators' buildings. At time being (2005) those spaces are free to be used for other purposes although the need of gable routings cannot not be underestimated today either.

Best return to investments on intelligence can be gained from the lowering costs of heating and modification of spaces. Still today despite the long existence of low energy ICT tools and latest development of energy effective building service and automation equipment, the heat loss of the electronic devices is high and the newest energy efficiently built office buildings need even less heating than they should because of the free energy gained from ICT tools. The consumption of electricity has been increasing during the last decade in office buildings. Modern energy-efficient intelligent offices are using lot of electricity. After the use of energy-efficient ICT tools and building service devices has increased, this problem of using high-priced electricity in the form of free energy for heating which could be handle with low-priced energy forms seems to be solved in the future.

A third important issue is the facilities management and maintenance of office buildings, which influences in long run to the economy of them as found during the IBs Survey. In the intelligent buildings there are sophisticated and complicated systems in more numbers − not only due to information networks but also due to active and versatile structures − to take care of than in a traditional buildings, where the facilities management is not the best possible due to many lacking in the knowledge how to run buildings cost-effectively.

5. Conclusions

The acquisition cost of intelligent buildings of 1990's were 30...40 per cent higher. The profitability is however remarkably better because of its potential for good incomes and permanency of market value. While costs of activities in the buildings are far higher than building investment costs there is no ground for extreme savings in spaces and equipment while it leads to dissatisfaction and symptoms which might mean also discomfort and low work motivation.

Based on life-cycle calculations, a cost-effective building may be described as follows: The building as well as components and systems inside have long lifetimes and do not need too much maintenance or there are no risks for breaking. They can be recycled on high level. The energy consumption of the building is in a relatively low level, the spaces are comfortable to use, safe, unobstructed and adaptable.

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Measuring Cyclical Fluctuations in Construction Investment

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Abstract

To adopt a more strategic perspective, practitioners responsible for construction investment need a clear understanding of the working of the factors that drive the cycles of construction industry. Unfortunately, the lack of uniformity in direction and magnitude of the cycles of construction investment has made difficult to create a uniform explanation, and there is no well-established model to account for some minimal set of basic stylized facts in this area.

Trying to overcome some of such limitations, this investigation[1] attempts to provide an insight into the dynamic relationship between construction investment cycles - and its residential and non-residential components - and the general business cycle in Israel. The basic question arises whether construction investment leads or lags the expansion or contraction of the general business cycle. The assumptions are tested through time series analysis of the record covering thirty-six years.

The empirical results show that cycles in public residential construction investment have a longer duration than those of other construction sectors. A cointegrating relationship exists between private residential and non-residential construction investment. The null hypothesis of Granger-noncausality from the construction investment – as well from its residential and non-residential construction investment component - to GDP is rejected, suggesting that past values of construction investment may help to predict GDP.

For policymakers formulating the macroeconomic policy that affects output and influences construction activity, the benefits from the findings are very practical. For construction firms, understanding construction investment volatility and using "cycle thinking" approach in their business activities, facilitates them in making more informed decisions.

This study contributes to theory by exhibiting a cyclical fluctuation process of construction investment that is not in accordance with most other models.

Keywords: cointegration, co-movement, deviation cycle, Granger-causality

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[1] The views expressed in this paper are those of the author. No responsibility for them should be attributed to the Israeli Central Bureau of Statistics.

1. Introduction

Subject to large and extensive fluctuations, construction investment is one of the most volatile components of the GDP. Construction needs long development periods and a long response time for stocks to adjust to new market conditions. Substantial gaps between planning and completion phases cause construction to respond cyclically to exogenous shocks.

The proliferation of cycle research has become a priority for large institutional investors such as real estate investment trusts, insurance companies, pension plans and their sponsors. In order to make more informed decisions on construction investment, a clear understanding of the factors that drive the working of the cycles in the construction industry - is necessary.

In recent decades, the empirical construction economics literature has focused on the cyclical behaviour of construction investment's components, and their relationship with output and other economic series. It presents a wide range of often contrasting results. Grebler & Burns [3] show that in the U.S. the number of fluctuations in total construction investment and some of its main components exceed that of the output series. They find an increasing volatility of private construction and its residential sub-sector, as well as all construction. Green [4] analyzes the impact of residential versus non-residential construction investment on the GDP throughout the business cycle, using the Granger-causality test. His findings show that residential construction investment Granger-causes the GDP, but it is not caused by it; while non-residential construction investment does not Granger-cause the GDP, but is Granger-caused by the GDP. Coulson & Kim [2] test the dynamics of both residential and non-residential construction investment with respect to the GDP, and find that residential construction investment shocks are more important in the determination of the GDP than non-residential construction investment shocks. Using data from Hong Kong, Tse & Ganesan [11] point out that the GDP tends to lead the construction flow - not vice versa; and the construction flows are less volatile than the GDP. Kim [6] examines residential and non-residential construction investment in the Korean GDP fluctuations and finds that non-residential construction investment shocks are more important in fluctuations of the GDP than residential construction investment shocks. Sabatés [10] uses a vector autoregression (VAR) methodology to examine the dynamic effect between construction investment and GDP in the USA, including sub-components of residential and non-residential construction investment. The analysis of impulse-response functions suggests that the GDP growth is mainly induced by a shock in consumption, followed by a shock in investments in the construction of single-family housing and other residential structures.

The aim of this study is to examine the dynamic effect between construction investment cycles – and its residential and non-residential components - and the GDP cycle in Israel. The basic question arises whether construction investment leads or lags the expansion or contraction of GDP. Stylized facts suggest that residential construction investment tends to be counter-cyclical, while the non-residential construction investment tends to be co-incidental with the macroeconomic cycle. To test these assumptions, time series methods are applied.

The organization of the remainder is as follows: a short description of the data is given, briefly describing the volatility of construction investment vs. the GDP, providing a rationale for cross-spectrum analysis of the relationship between these two main series. Next, the construction investment cycles are estimated, and the cyclical behaviour of construction investment and its main sub-components is discussed. The cointegration and Granger-causality test results are further examined in order to show the impact of construction investment on the peaks and troughs of the GDP growth cycle. Finally, the implications of the findings are discussed and the concluding remarks are presented.

2. Data Description and Statistical Transformations

In order to estimate the cycles in Israeli construction investment, quarterly data are used. To accomplish this task, seven series from the Israeli Central Bureau of Statistics are used ($x_{i,t}$, where $i=1,..,7$, and $t=1,..,144$, denotes quarters, from the 1st quarter of 1968 to the 4th quarter of 2003): five series on the gross domestic capital formation in construction: construction investment (*Construction I*), residential construction investment (*Residential CI*), private residential construction investment (*Private RCI*), public residential construction investment (*Public RCI*) and non-residential construction investment (*Non-RCI*), which are supplemented by two "reference" series on: the GDP (*GDP*) and private consumption expenditure (*C*).

All series are deflated using their respective price index, are seasonally adjusted, and usually, are transformed into natural logarithms. In order to detrend the data, first differences and the Baxter-King band-bass filter are used.

The results of the Phillips-Perron unit root test indicate, that the null hypothesis of non-stationarity of the seven series in their level form is not rejected by using a *1%* statistic significance level (Table 1).

Table 1: Results of the Phillips-Perron unit root test (minus signs are omitted for simplicity)

Series	Level, $x_{i,t}$				First difference, $Ln(x_{i,t}) - Ln(x_{i,t-1})$			
	Trend		No trend		Trend		No trend	
	2 lags	4 lags	2 lags	4 lags	2 lags	4 lags	2 lags	4 lags
Construction I	1.20	1.33	1.57	1.60	9.61	9.64	9.50	9.54
Residential CI	1.99	2.17	2.23	2.31	8.89	8.98	8.70	8.80
Private RCI	1.41	1.45	1.97	1.98	10.77	10.76	10.49	10.47
Public RCI	2.53	2.88	2.56	2.91	7.28	7.66	7.27	7.64
Non-RCI	.87	1.04	.88	.94	13.71	13.64	13.75	13.68
GDP	1.38	1.40	.27	.27	16.26	16.07	15.64	15.39
C	1.27	1.27	2.04	2.06	13.68	13.92	13.69	13.91

The critical values of the test are: *4.04* and *3.45* with trend, and *3.51* and *2.89* without trend, at *1%* and *5%* significance levels, respectively.

With the application of first difference of the logarithm form, all the series that are investigated in this article become stationary.

3. Cycle Volatility

The cycle theory claims that cyclical fluctuations may be connected to volatility and long-term growth rates. The volatility of construction investment and the GDP is measured using the standard deviation of growth, in percentages. For each year, the standard deviation and the mean of the expression $((1+Ln\ (x_{i,t}/x_{i,t-1}))^4-1)*100$ are computed. The volatility is plotted against each year (Figure 1) and against the average growth rate of each year (Figure 2).

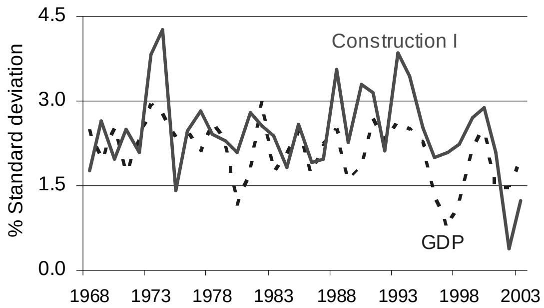

Figure 1: Cycle volatility of construction investment and GDP

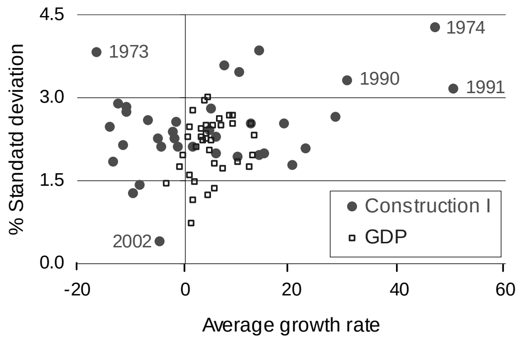

Figure 2: Cycle volatility and growth rate of construction investment and GDP

Construction cycle volatility is subject to much larger relative variations than the GDP, with standard deviation reacting instantly to outliers of both series (Figure 1). The linear relationship between volatility and growth in construction investment has a positive low value (*ρ=.3579,* for *df=34*, and a non-directional probability of *.0321* for the null hypothesis *ρ=0)* (Figure 2). Miles & Scott [9] suggest that the business cycle volatility has a mixed effect of negative and positive implications on the long-run growth rate. On the one hand, construction cycle fluctuations can harm the construction industry: they generate volatility not just in its output but also in firm profits and cash flows, which may delay future investment; initiators of real estate development and construction will be reluctant to commit cash or borrow funds to finance investment if there is substantial risk of a serious contraction in the construction industry; unemployed construction workers lose certain skills and their productivity declines - this obstructs their efforts to regain employment when recovery occurs, and may permanently diminish construction output.

On the other hand, recessions in the construction industry may have some beneficial effects on the construction growth rate. When the construction industry enjoys expansion and production means are used intensively, so that overtime is high, it is costly for construction firms to stop activity and reorganize their production process to improve efficiency. If construction firms are already at full capacity when they receive additional orders, these new orders cannot be met, so firms start increasing prices to choke off demand. However, during recessions construction workers have spare time and equipment is idle; this is a time for firms to restructure and increase productivity. Intense competition during recessions also provides construction firms with incentives to reorganize and to improve efficiency, so that growth in the construction industry can accelerate when the industry recovers.

4. Sinusoidal Oscillations

Spectral analysis is a modelling procedure using sinusoidal components, whose purpose is to determine how important cycles of different frequencies account for the behaviour of a time-series variable. To compute the phase spectrum and the squared coherency (Figure 3 and Figure 4), differenced *logs*, $Ln(x_{i,t})–Ln(x_{i,t-1})$, are used. The dashed lines represent the estimated two standard error bands, and the shaded areas represent so-called “business cycle frequencies” (*8* to *32* quarters).

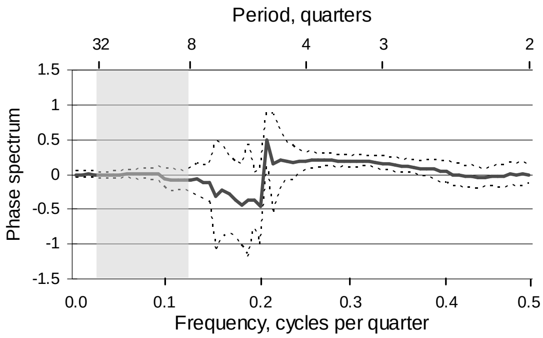

Figure 3: Phase spectrum of GDP by construction investment

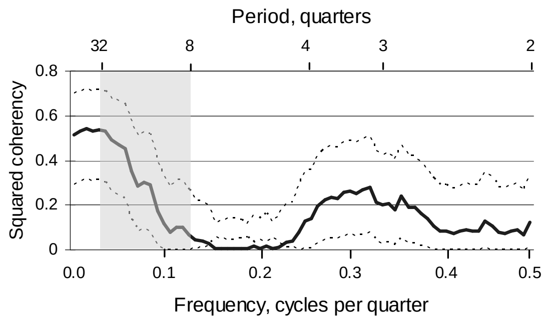

Figure 4: Squared coherency of construction investment and GDP

The phase spectrum, as a measure of the extent to which cycles in one series lead or lag behind cycles in the other, suggests that long-term fluctuations (frequency near zero) and short-term fluctuations (frequency near *0.5*) for construction investment and the GDP are nearly in phase (Figure 3). The phase spectrum starts at zero and then decreases, indicating that construction tends to peak slightly before the GDP at intermediate frequencies. This is reasonable, because controlling factors in the construction industry are the availability of money and credit in the mortgage markets. When the aggregate economy is prosperous and costs are rising, investors can find more lucrative investments than banks and real estate loans. This decreases the availability of money for construction investment and causes a slump in the construction industry. During tight money markets, construction loans carry higher interest rates; builders pass the high costs on to buyers or accept a lower profit. Conversely, interest rates decline during a depression, so saving institutions attract more money with which to finance construction.

The squared coherency, as a measure of the degree to which two series are jointly influenced by cycles of a given frequency, is near *0.6* at low frequency, indicating a significant correlation between construction investment and the GDP in their long-run movements **(**Figure 4). The squared coherency in the figure becomes smaller at higher frequencies. The estimated phase spectrum can vary at high frequencies, as a result of this low correlation between construction investment and the GDP at high frequencies. High-frequency oscillations in construction investment tend not to be closely associated with short-run movements of the GDP. It takes considerable time to obtain local authorities' building approval, secure financing, and complete actual construction, and this lag time accounts for many radical swings in supply and demand.

5. Common Cycles

Cyclical dynamics are usually modelled as part of a time series model. In this section, the integrated time series are Baxter-King band-bass filtered [1], and the turning points of the deviation cycles are formally located using a Phase Average Trend (PAT) program [12]. The Baxter-King method is a finite moving-average approximation of an ideal band-pass filter, designed to pass through components of time series with fluctuations of between *6* and *32* quarters while removing higher and lower frequencies as "non-cyclical". PAT is a multi-step, successive-approximation approach dictated by the objective of deriving estimates that reflect in a reasonable way the interplay of longer (trend) and shorter (cyclical) movements. The $x_{i,t}$ time series is decomposed additively into a nonstationary (trend) component $T_{i,t}$ and a stationary (cyclical) component $C_{i,t}$ in order to generate the underlying model $x_{i,t} = T_{i,t} + C_{i,t}$. The number of cycles is listed in Table 2, along with the duration of the corresponding above-trend and below-trend phases.

Table 2: Deviation cycles and their duration by type of phase, 1967-2003

Series	Number of cycles	Duration, quarters					
		Cycle		Expansion		Contraction	
		Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Construction I	6	16.8	4.3	8.0	3.2	8.8	2.1
Residential CI	6	15.8	3.1	7.8	1.2	8.5	3.0
Private RCI	7	15.7	3.6	7.7	1.8	8.0	2.1
Public RCI	4	26.3	10.0	16.8	10.2	9.5	.6
Non-RCI	8	16.5	3.4	8.4	2.6	8.1	1.6
GDP	8	15.6	3.8	8.8	2.9	6.9	1.9
C	7	17.7	2.8	8.3	1.1	9.4	3.4

The duration of construction cycles shows moderate differences, excluding public residential construction investments. The asymmetric cycle of public residential construction investment exhibits a long expansion period that might be attributed to government attempts to accommodate mass migration waves, but the evidence on this point is not verified. The contraction period, however, is much shorter, with a small standard deviation. The presence of such *sui generis* cycles indicates that this specific construction sector can fluctuate without parallel movements in other construction sectors, or in the general output.

When distinguishing between cycle phases and erratic changes, the question arises whether the cyclical movements of various construction investments are synchronous, or out of phase, with the GDP, and with each other. The co-movement differs from one pair of series to another (Figure 5 and Figure 6). Shaded areas represent recessionary periods reported by Marom et al. [7]. Construction investment and the GDP do not seem to behave counter-cyclically throughout most of the analysis period (Figure 5), as opposed to the residential and non-residential construction investments, which do not seem to operate pro-cyclically during most of the analysis period with respect to each other (Figure 6). An expansion of residential construction investment may be accompanied by augmented retail and consumer service facilities and utility extensions, which appear in non-residential construction investment. Some of these investments may be simultaneous and others sequential. The often contrary cyclical fluctuations of the investment in different construction sub-sectors may neutralize each other, with the result that total construction investment moves relatively close to a trend line.

To elucidate the relationship between cycles, and determine whether two series co-move, we can associate them with binary random series that take the value one when the series are in expansion, and zero when they are in contraction. The concordance index C_{xy} of the cycles of two-time series x_t and y_t is mathematically defined by Harding & Pagan [5] as the fraction of time when they are in the same state S (phase):

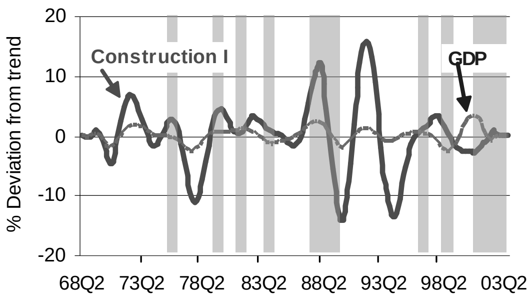

Figure 5: Cyclical component from Baxter-King filter for construction investment and GDP

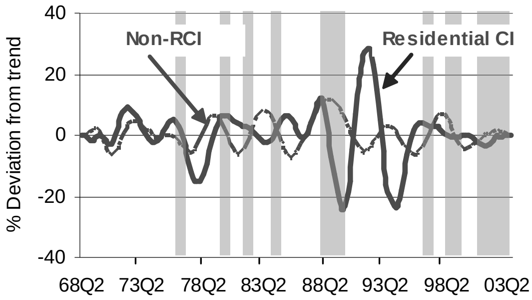

Figure 6: Cyclical component from Baxter-King filter for residential construction investment and GDP

$$C_{xy} = n^{-1}\left[\#\{S_{x_t}=1,\ S_{y_t}=1\}\right] + n^{-1}\left[\#\{S_{x_t}=0,\ S_{y_t}=0\}\right] \qquad (4.1)$$

The concordance index statistic presented in (4.1) is bounded by construction to the range [0,1] and has the technical advantage that it is entirely non-parametric. If the series x_t and y_t were pro-cyclical, then the index C_{xy} would be one, while a value of zero marks it down as being counter-cyclical.

In Israel, residential construction investment moves together with the GDP in its expansion and contraction phases (C_{xy} =.67, at *5%* significance level) (Table 3). This evidence does not confirm the stylized fact of counter-cyclical behavior of residential construction investment.

Table 3: Concordance index statistics

Series	Construction I	Residential CI	Private RCI	Public RCI	Non-RCI	GDP	C
Construction I	**1.00**						
Residential CI	.83[a]	**1.00**					
Private RCI	.71[a]	.69[a]	**1.00**				
Public RCI	.66[b]	.72[a]	.48	**1.00**			
Non-RCI	.66[b]	.49	.55	.44	**1.00**		
GDP	.64[c]	.67[b]	.65	.63	.56	**1.00**	
C	.59	.54	.63[c]	.44	.54	.72	**1.00**

Figures marked *a*, *b* and *c* are statistically significant at *1%*, *5%* and *10%* significance levels, respectively. The critical values are computed for the test proposed by McDermott & Scott [5].

6. Common Trends

Two or more series may have trends and cycles in common. The difference between the two concepts is that common cycles are a short-run phenomenon concerned with co-movement between stationary series, while common trends (and cointegration) are concerned with long-run relationships between sets of non-stationary series. Cointegration refers to the existence of a stationary linear combination of two (or more) non-stationary series that share a stochastic trend.

Potential cointegration among different construction investment categories (in their natural logarithm form) is estimated using the Johansen rank (r) test (Table 4).

The null hypothesis of non-cointegration is rejected when the trace statistic is greater than the test's critical value. The critical values of the Johansen test are for a non-restricted trace, at 1% and 5% significance levels, 19.69 and 15.34 respectively for r=0, and 6.64 and 3.84 respectively for r=1. The critical values for the restricted trace test, at 1% and 5% significance levels, are 24.74 and 19.99 respectively for r=0, and 12.73 and 9.13 respectively for r=1. Figures marked a and b are statistically significant at 1% and 5% levels of significance, respectively.

Table 4: Results of Johansen rank test for cointegration

Series $Ln(x_{i,t})$	Trace statistic				Intercept restriction test for *r=1*		Errors correlation
	No restriction		Under restriction				
	r=0	*r=1*	*r=0*	*r=1*	Chi-square	*p*-value	
Residential I, Non-RCI	20.78[a]	1.09	23.23[b]	3.43	2.35	.1257	.4411
Private RCI, Non-RCI	25.46[a]	.52	28.27[a]	2.17	1.65	.1992	.5211
Public RCI, Non-RCI	14.73	1.05	16.93	3.19	2.14	.1439	.1561
Private RCI, Public RCI	22.48[a]	10.79[a]	24.79[a]	11.16[b]	.37	.5422	.2597

While no cointegration relationship is observed between public and non-residential construction investment, the test statistics strongly support the presence of one cointegrational vector for private residential and non-residential construction investment. Whether or not the intercept restriction is imposed, the hypothesis of *r=0* cointegrating vectors between private residential and non-residential construction investment is rejected. Johansen's test indicates a single (*r=1*) cointegrating vector, and hence a single common trend. The null hypothesis, which the intercept restriction holds, is not rejected, using the chi-square test *1.65* with *1* degree of freedom.

If we normalize on non-residential construction investment series, the estimated cointegrating vector is *(1, -2.0207)*. The structural interpretation of the cointegration equation implies that the long-run relationship between the two series is: $Non\text{-}RCI_t = 9.1592 + 2.0207 \cdot Private\ RCI_t + e_t$. Thus, the coefficient on private residential construction investment indicates, as expected, a positive relationship between private residential and total non-residential construction investment over a long period of time; i.e., support for the hypothesis that private residential construction investment crowds in non-residential construction investment.

We can consider the non-residential construction investment as a deviation from the long-run equilibrium equation. To model the adjustment of present non-residential construction investment towards this long-run equilibrium with private residential construction investment, we can incorporate an error correction model (*ECM*), which links short-run instability to long-run stability:

$$\begin{pmatrix} \Delta\, Non-RCI_t \\ \Delta\, Private\, RCI_t \end{pmatrix} = \begin{pmatrix} \underset{(.134)}{.101} \\ \underset{(.130)}{.637} \end{pmatrix} + \begin{pmatrix} \underset{(.015)}{.013} & \underset{(.030)}{-.025} \\ \underset{(.014)}{.070} & \underset{(.029)}{-.142} \end{pmatrix} \begin{pmatrix} Non-RCI_{t-1} \\ Private\, RCI_{t-1} \end{pmatrix} + \begin{pmatrix} \underset{(.097)}{-.157} & \underset{(.092)}{.020} \\ \underset{(.094)}{.192} & \underset{(.089)}{.025} \end{pmatrix} \begin{pmatrix} \Delta Non-RCI_{t-1} \\ \Delta Private\, RCI_{t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} \underset{(.099)}{.081} & \underset{(.086)}{-.077} \\ \underset{(.010)}{-.111} & \underset{(.083)}{-.051} \end{pmatrix} \begin{pmatrix} \Delta Non-RCI_{t-2} \\ \Delta Private\, RCI_{t-2} \end{pmatrix} + \begin{pmatrix} e_{Non-RCI,t} \\ e_{Private RCI,t} \end{pmatrix} \qquad (5.1)$$

where Δ is the difference operator $(\Delta x_{i,t} = x_{i,t} - x_{i,t-1})$ and the asymptotic standard errors are presented in parentheses under the estimated coefficients. The error correction model explains how quickly the series respond to deviation from the long-run relationship. We deduce from Equation (5.1) that the current changes in non-residential investment are explained by the intercept, the adjustment towards the long-run relation with private residential investment, and the past changes in non-residential investment and in private residential investment. The error variance matrix is: $\sum = \frac{1}{1000}\begin{pmatrix} 4.19 & 2.12 \\ 2.12 & 3.95 \end{pmatrix}$ indicating a correlation *.5211* between the errors.

6.1 Causality Test Results

In order to formulate a policy of economic stability it might be interesting to determine, using the Granger-causality test, the impact of construction investment on the peaks and troughs of the business cycle. Granger-causality is an econometric representation of the timing of causation. A series $x_{1,t}$ is said to be "Granger-causing" a series $x_{2,t}$ when a prediction of $x_{2,t}$ on the basis of its past history can be improved by further taking into account the previous period's $x_{1,t}$.

The results for the Granger-causality test of first differences of the natural logarithms of the series, $Ln(x_{i,t}) - Ln(x_{i,t-1})$, indicate a one-way causation process (Table 5).

Table 5: The Granger-causality Wald test results

Caused series / Causal series	GDP		Causal series / Caused series	GDP	
	Chi-Square	*p*-value		Chi-Square	*p*-value
Construction I	8.69	.0032	Construction I	2.09	.1482
Residential CI	4.82	.0282	Residential CI	3.30	.0692
Non-RCI	6.93	.0085	Non-RCI	.07	.7872

The two directions of causality are shown in this table: firstly where construction investment Granger-causes GDP (left-hand-side), and secondly where GDP Granger-causes construction investment (right-hand-side). The regression is run for the natural logarithm of the series by setting the order of lags=*6*, with *1* degree of freedom. From the *p*-values, we can reject the null hypothesis of Granger-noncausality from the construction investment to the GDP, using a *5%* significance level. This result formalizes the stylized fact that construction investment cycles lead GDP cycles. On the other hand, from the *p*-values we fail to reject the null hypothesis of Granger-noncausality from the GDP to construction investment, using a *5%* significance level.

Residential construction is the major component of the Israeli construction industry. Thus, it is not surprising that we can reject the null hypothesis that residential construction investment, like total construction investment, does not Granger-cause the GDP; and at the same time, we cannot reject the null hypothesis that the GDP does not Granger-cause residential construction investment. Finally, non-residential construction investment appears to Granger-cause the GDP, but the GDP does not seem to Granger-cause non-residential construction investment.

In conclusion, the series of construction investment and its residential and non-residential components seem to individually Granger-cause the GDP, but the GDP does not appear to Granger-cause them; this is a significant stylized fact. The statistical implications of this model structure is that future values of total, residential and non-residential construction investments, are influenced only by their own past, and not by the past of the GDP; whereas future values of the GDP are influenced by the past of both the GDP and construction investment and its components. These results are striking; but unfortunately, Granger-causality can never prove causality with certainty, because there are several other factors that could affect the test results. The construction investment series may predict the GDP without necessarily causing the GDP.

7. Discussion

Evidence shows that the linear relationship between volatility and growth in construction investment is low, suggesting that high volatility does not essentially reduce the growth rate of construction investment. The implication of this finding to governments is that switching from the cyclical equilibrium to a corresponding acyclical one does not raise the long-run growth in construction investment. For construction businesses, this means that they need to reorganize their production and improve efficiency in recession periods, in order to be ready to accelerate when the construction industry recovers.

Interestingly, the public residential construction investment cycle appears very dissimilar compared to other construction investment cycles, in terms of long duration and lack of symmetry. Cyclical asymmetry is usually connected to high volatility, asymmetric shocks and asymmetric shock-transmition mechanisms. For construction firms focusing on public residential projects, this means that they should carefully consider the position of construction investment cycles in their analysis. In order to make better investment decisions and to forecast more accurately future returns, they should use cyclical rather than linear estimates.

The results also suggest that no cointegration relationship is observed between public residential and non-residential construction investment. For governments, this means that their policy of promoting residential construction investment may be not sufficiently accompanied by similar efforts in the domain of non-residential construction investment. For businesses focused on public residential construction, this means that although they develop the residential space itself, as well the immediate residential environment, this is not the case with regards to the infrastructure of the immediate neighborhood.

8. Conclusions

The cyclical fluctuations of construction investment in the Israeli economy are examined, using different time series methods. The empirical results show that construction grows through cycles of expansions and contractions that vary widely in amplitude and duration, but its fluctuations do not seem to follow a deterministic cyclical pattern with distinct phases of finite duration. High values of cycle volatility seem to represent a dominant feature of construction investment. The co-movement of construction investment and GDP cycles exhibits significant coherency at low frequencies. The concordance index shows that residential investment characteristically moves together with the GDP in its phases of expansion and contraction. The non-stationary series of private residential and non-residential construction investment are cointegrated, sharing a common stochastic trend. The results show that construction investment, as well as each of its components - residential and non-residential - seems to Granger-cause the GDP, but the GDP does not appear to Granger-cause any of them. These findings are partially compatible with the results obtained by Green [4], who concludes in his experiment that residential construction investment appears to Granger-cause the GDP, but non-residential construction investment does not Granger-cause the GDP. However, the results are not in accordance with those obtained by Tse & Ganesan [11], who find that the GDP tends to lead construction flows.

This study contributes to theory by providing evidence on stylized facts, formulating additional stylized facts and exhibiting a cyclical fluctuation process of construction investment that is not in accordance with most other models. Furthermore, it contributes to a better understanding of the correlations of construction investment with other macroeconomic series.

These conclusions provide a basis for future work. The one-way Granger-causality found between construction investment and the GDP needs further research, for the purpose of developing a transfer function model on Israeli data to study whether the GDP's response to a residential construction investment shock is greater than that of the response to a non-residential construction investment shock.

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A Study on the Cost Planning System for Building Construction Projects

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Abstract

The purpose of the this research is to develop the cost planning system in order to use it step by step during the production process on the public office construction projects. The system consists of Master planning subsystem and Design phase subsystem. Former one is the forecasting model with data mining and multi-regression analysis. Another is the cost calculation of subsystem based on the input data, enabling prediction of quantity and costs based on drawing information. Accuracy and operational performance are satisfied on the developed cost planning system, and it is easy to apply it to change order and VE analysis.

Keywords: Construction Management, Construction Cost, Cost Control, Estimation, Quantity Surveyor

1. Introduction

The purpose of the this research is to develop the cost planning system in order to use it step by step of the production process on the public office construction projects.

The purpose of the research can be given four points as follows:

1) System development for cost planning step by step to achieve business decisions

2) Improvement for traditional cost planning system by public clients

3) System development for change order and Value Engineering clarified predictable construction costs

4) To reduce workloads for estimating construction costs.

2. Previous Research

Previous research concerning cost planning is based on literature and interview research as shown in Table1.

Table 1: Literature and Interview research

Literature research	Interview research
- A lot of predicting techniques are based on limited design information. - When predicting costs directly, fudge factor is included by changing commodity price and regional differences. - These errors are not included by the technique of predicting quantity.	- There are many techniques of measuring quantity based on schematic drawings from initial project phase. - The cost calculation based on measuring quantity by drawings is essential to adopt VE technique and change orders. - It is effective for saving the time and effort to set up an automatic design, standard specification, and recommended value.

3. Problems of Current System

The problems of the existing system are as follows:

- § It is too dependent on the unit price (per unit area) on the floor area for the past actual result value.
- § Since cost calculation by work package is calculated, the cost balance and fluctuation cannot be obtained.
- § It is difficult to reflect design intention to VE review and change order.
- § There is some possibility of input wrong data, and the work of data input is large as quantity surveyors gather numerical value from drawings not using electrical way.
- § As the result of verifying the accuracy of the existing system, the rate of an average error is 22.83%, and the accuracy rate is very bad.

4. Development of Cost Planning System

The development of cost planning system is based on each subsystem. The different types of the systems are required in master planning phase and in design phase. It is, therefore, that two subsystems are developed for master planning phase and design phase.

4.1 Concept of Master Planning Subsystem

Requirements of the system are:

- § The cost estimate for determining the total budget based on block plan drawings (the scale is 1:500) is required in planning phase.

Conditions of the system are:

- § Available design information, such as total floor area, building area, number of stories, lot area, etc., is limited in this phase.
- § It is necessary to evaluate alternative proposals within a limited amount of time

System Development Policy are:

- § It estimates costs, based on the actual past data in the existing system, using statistical method.
- § The prediction techniques are used by Multi regression analysis is used to estimate costs from the limited design-information, and as the result of it, the variable will be found.
- § By using data mining on the system, building quantity and materials are developed automatically.

4.2 Concept of Design Subsystem

Conditions of the system are:

- § Progress and developing details in temporary works, earthworks, soil works are different by project types.
- § The differences of predicting costs among projects in building frame works are little in the case of measuring quantity.
- § The cost of finish works depends on finish materials. It is so easy to define the grade of finish materials by standard specification in public works.

Requirements of the system are:

- § It is required that cost predicting which added new information and based on detail drawings helps design development.

Conditions of the system are:

- § Cost calculation, which is based on past performance costs in temporary works, earthworks and soil works, is able to cut in fine in progress of design development.
- § It is necessary to figure out the detail quantity of each element in building frame works and finish works. When the project is not yet decided a quality grade, the lowest grade is set up and the degree of project implementation is to calculate.

- § A predictable cost, which is able to control certain amount of degree, calculates simultaneously in order to support decision making such as change order and VE.

- § In addition these systems, it is important thing to decrease data input error.

System Development Policy are:

- § Predicting costs in temporary works, earthworks and soil works are defined default measures based on analysis of past projects. The system is able to replace default data to real measured data in such works.

- § The feasibility costs are based on exact quantity in concrete works and finishing works. If there had some difficulties to find out quantity, the level of materials are set as lowest grad, because the accuracy of predictable costs is rising.

- § The system contained both costs and material grade can be developed, which it is easy to update costs by progress of construction product process.

5. Developed Cost Planning System

5.1 Outline of Cost Planning System

The flow chart of the developed cost planning system is shown in Figure 1.

In master planning subsystem, the forecasting model is using the method combined “data mining” and “multi-regression analysis”, which is expressed with tree structure, and set to each wooden leaf and each wooden paragraph as multi-regression formula. The result, which was adapted for the actual result data (Total construction costs) of the past government building projects, is described below:

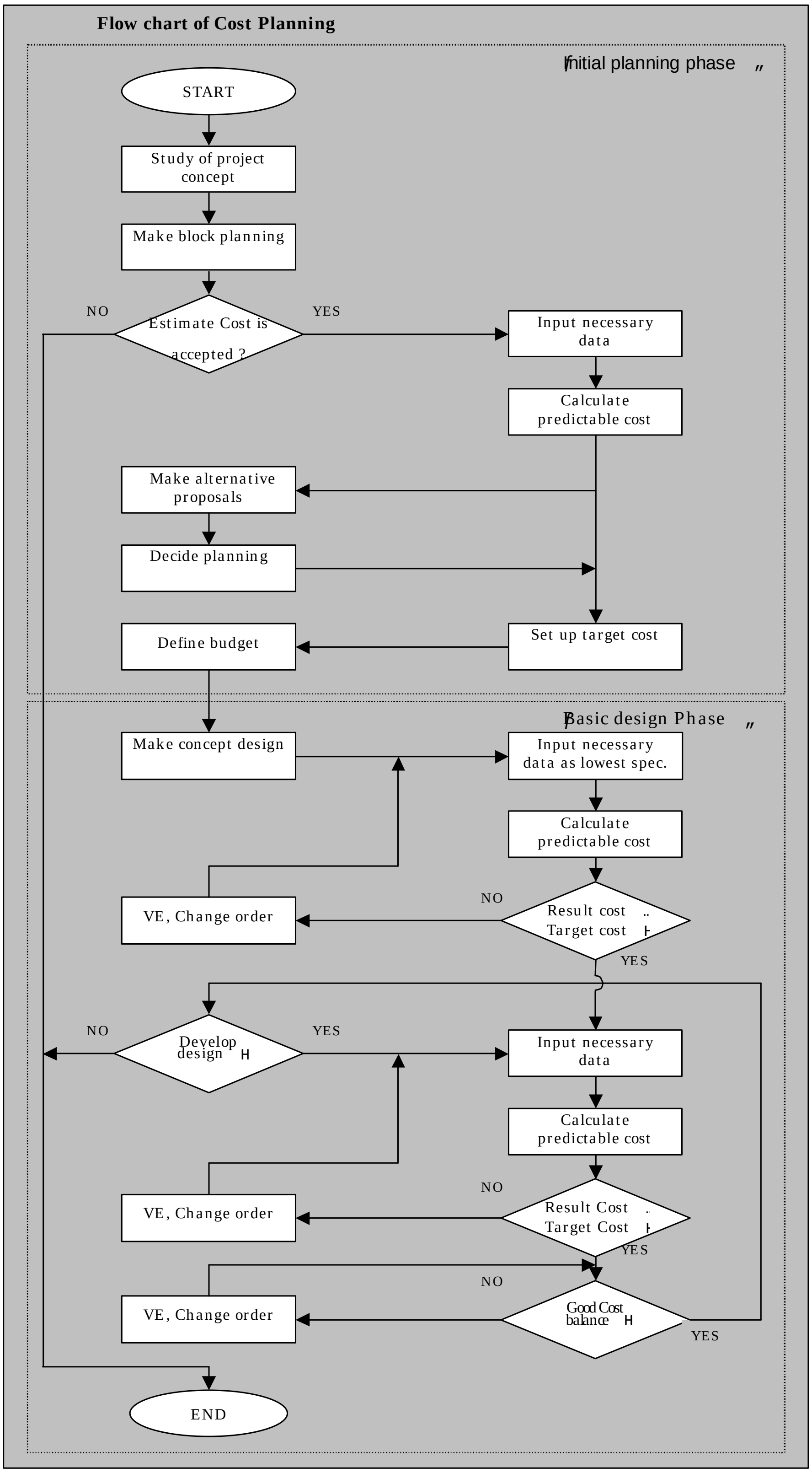
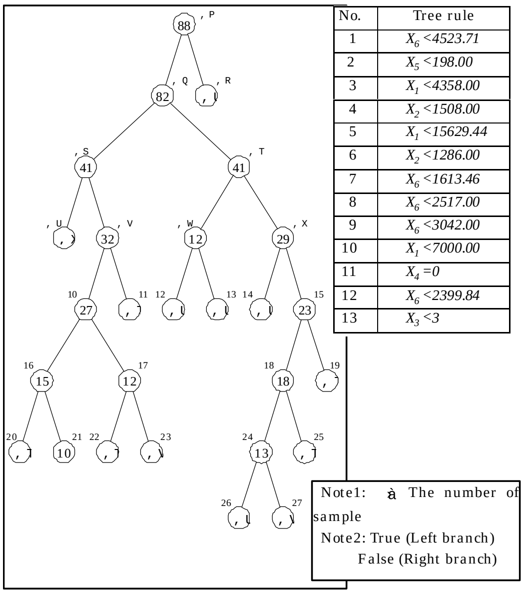


Fig. 1 System-composition



No.	Tree rule
1	$X_6 < 4523.71$
2	$X_5 < 198.00$
3	$X_1 < 4358.00$
4	$X_2 < 1508.00$
5	$X_1 < 15629.44$
6	$X_2 < 1286.00$
7	$X_6 < 1613.46$
8	$X_6 < 2517.00$
9	$X_6 < 3042.00$
10	$X_1 < 7000.00$
11	$X_4 = 0$
12	$X_6 < 2399.84$
13	$X_3 < 3$

Figure 2: Data mining

Notes: Each explanation variable and purpose variable as follows.
X1: Main building total floor area (m2)
X2: The first floor's area (m2)
X3: The number of ground stories
X4: The number of underground stories
X5: Ancillary building's floor area (m2)
X6: Vacant lot area (m2)
Y0: Construction cost (Japanese Yen)

No.	Regression formula
, P	$Y_0 = 84457.17\ X_1 + 140860052.04$
, Q	$Y_0 = 93722.93\ X_1 + 83186074.58$
, R	$Y_0 = 110481.50\ X_1\ \ 461309526.68\ X_3\ \ 174461.60\ X_3 + 2372090308.31$
, S	$Y_0 = 95636.14\ X_1 + 54892717.79$
, T	$Y_0 = 94353.56\ X_1 + 92266978.05$
, U	$Y_0 = 197222.01\ X_1\ \ 187594.33\ X_2\ \ 107095231.32\ X_4 + 87431410.75$
, V	$Y_0 = 96803.42\ X_1 + 40119219.33$
, W	$Y_0 = 56764.97\ X_1 + 61207707.97\ X_3\ \ 29104.70\ X_6 + 65791.81\ X_2 + 4104541.71$
, X	$Y_0 = 92850.40\ X_1 + 102939690.50$
10	$Y_0 = 89692.89\ X_1 + 103854442.51$
11	$Y_0 = 345870.31\ X_1\ \ 4115373944.27$
12	$Y_0 = 101100.07\ X_1\ \ 33760.37\ X_6\ \ 54335.49\ X_2 + 172212339.84$
13	$Y_0 = 93706776.50\ X_3 + 274857.26\ X_2 + 26315.92\ X_1 + 65791.81\ X_2\ \ 318989018.19$
14	$Y_0 = 111512.10\ X_1\ \ 586664.57\ X_6\ \ 36686.41\ X_5 + 894618505.81$
15	$Y_0 = 90608.60\ X_1 + 120935313.05$
16	$Y_0 = 82242.34\ X_1 + 124229522.08\ X_4 + 58817747.91$
17	$Y_0 = 270861884.21\ X_3 + 157203618.75$
18	$Y_0 = 91290.93\ X_1 + 110741126.41$
19	$Y_0 = 412982.53\ X_5 + 226762966.97$
20	$Y_0 = 122853.01\ X_1 + 114382.19\ X_6\ \ 25743604.02\ X_4\ \ 241383825.96$
21	$Y_0 = 71858.58\ X_1 + 207370268.52\ X_4 + 153351016.31$
22	$Y_0 = 103795.62\ X_1 + 137845167.461$
23	$Y_0 = 302265508.96\ X_3 + 87809.92\ X_2\ \ 259065068.90$
24	$Y_0 = 96495.08\ X_1 + 85518228.77$
25	$Y_0 =\ \ 48674406.28\ X_3 + 829609122.58$
26	$Y_0 = 95653.82\ X_1 + 74933195.02$
27	$Y_0 = 98269.26\ X_1\ \ 13685.75\ X_2 + 128891929.05$

Figure 3: Regression Formula of cost calculation system

In design phase, cost calculation of subsystem is performed based on the input data from STEP1 to STEP18 as shown figure 4. Furthermore, two tools are created for the purpose of enabling prediction of quantity and costs based on drawing information.

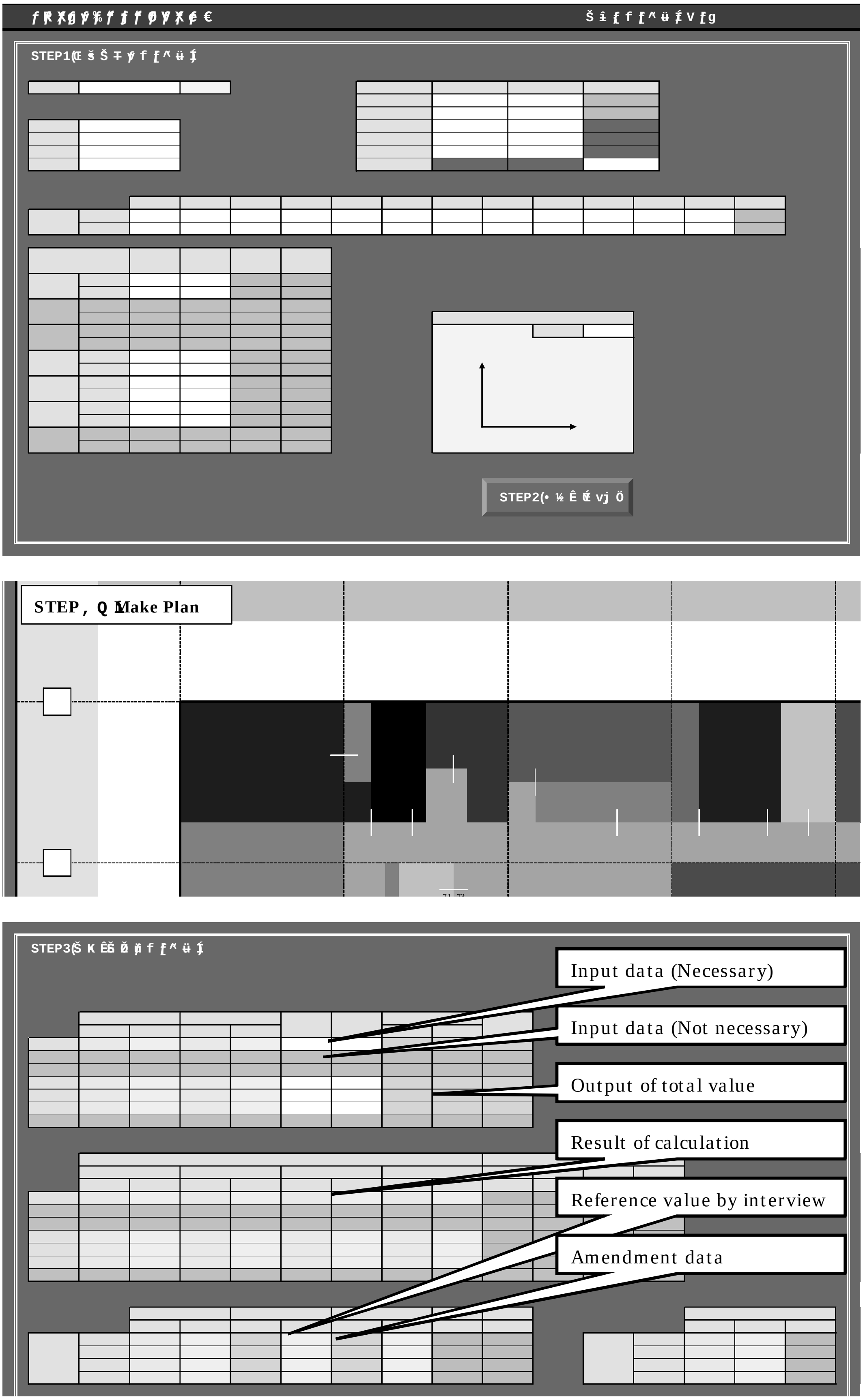


Figure 4: Example of input sheet

5.2 Plan Creating Tool

The quantity, which is based on the actual design information, is necessary to develop detail design and change order. It takes time and efforts to pick each quantity from drawings, which have the possibility to make calculation mistakes. We, therefore, developed new tool, which can compute each quantity automatically and develop detail design on Excel (Microsoft Excel).

As shown in Fig. 5, the room number corresponding to each cell on Excel can be input based on 1/500 plan, and each quantity can be automatically created using VBA (Microsoft Visual Basic for Applications). This tool has calculated each item automatically.

Item	Explanation
Room floor area□ ¡ Ø□ j	Quantity measuring by each story and each room
Peripheral Length of room□ ṁ□ j	Quantity measuring by each story and each room
Interior wall area□ ṁ2□ j	Quantity measuring by each story and each room
Number of column	Quantity measuring by each story
Total span□ ṁ□ j	Quantity measuring by vertical and horizontal axis
Exterior peripheral length□ ṁ□ j	Quantity measuring by vertical and horizontal axis
Number of opening	Quantity measuring by each type and each room

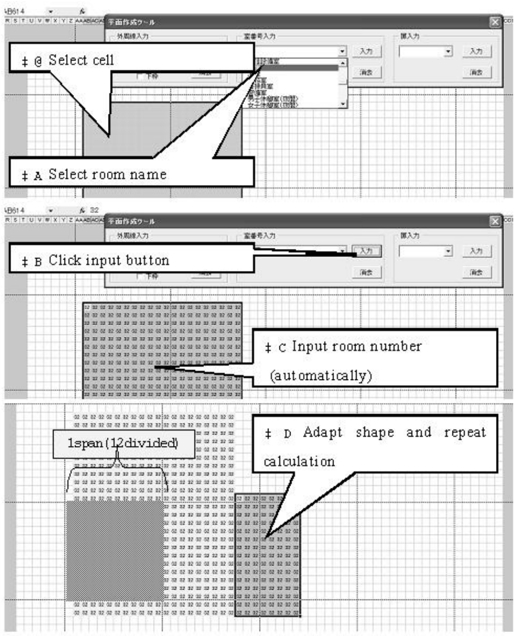


Figure 5: Room number input by plan creation tool

5.3 Section Creating Tool

The component in master plan phase is not based on cross section size to calculate structure strength. When you calculate each amount of bodies, the information about a cross-sectional size is calculated. It is necessary to estimate the information about a cross-sectional size such as pillar and beam length. Structural analysis was performed to 60 standard models with the drawing information, which is based on the analysis result. The system has recommendation section setting tool.

An example of regression analysis with each parameter and each stress is as follows:

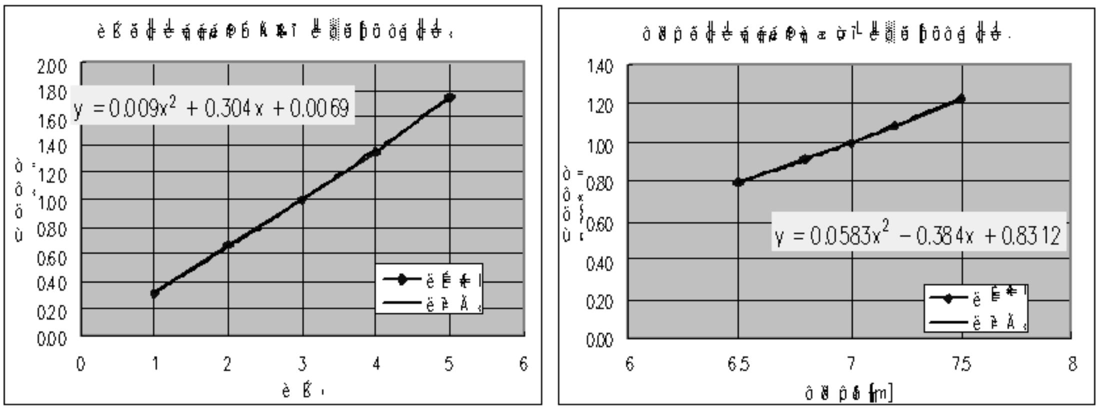


Figure 6: Example of regression analysis result (extract)

6. Evaluation of the System

6.1 Verification about the Precision

In the planning and site selection subsystem, it divided 88 sample data into the test data (22), the training dater (66) and examined 4-cycle verification. As the result of it, the precision is improving than existing systems.

In the master plan and the general plan subsystem, it verified about the amount of money with the quantity of concrete and finishing and each item for the actual result data in the past. The result (only the quantity) shows as follows:

6.2 Verification about the Operability

Although there is a total of 62 items to be used to estimate cost in design phase, only 25 items are necessary to revise input data. It can be said that accuracy of estimation is much improved.

6.3 Design Support

In the design phase, it is easy way to compare calculated costs with costs of similar projects. One part of the quantity of concrete and finish is measured and the costs of finish are estimated by standard level. This system is, therefore, to support for design development because of following factors;

1) Validity of proposal plan becomes clear by comparing each item with similar projects, and the advisability of proposal project should be judged.

2) Moreover, it can be gained whether cost has exceeded or not from item level by compared with the similar projects, and it can be used as the indicator of design change and VE.

3) Examination of the implement ability of a project is more possible by calculation result based on planning.

4) The quantity of finish works is based on actual measures, so it is firmed that the differences of cost estimation is minimum.

5) Therefore, when design changes have happened, it can easily respond by fluctuating quantity and changing specification.

6) Design change is supported by changing the specification of each part on the system.

Furthermore, VE and change order is easy by comparing the costs of standard specification.

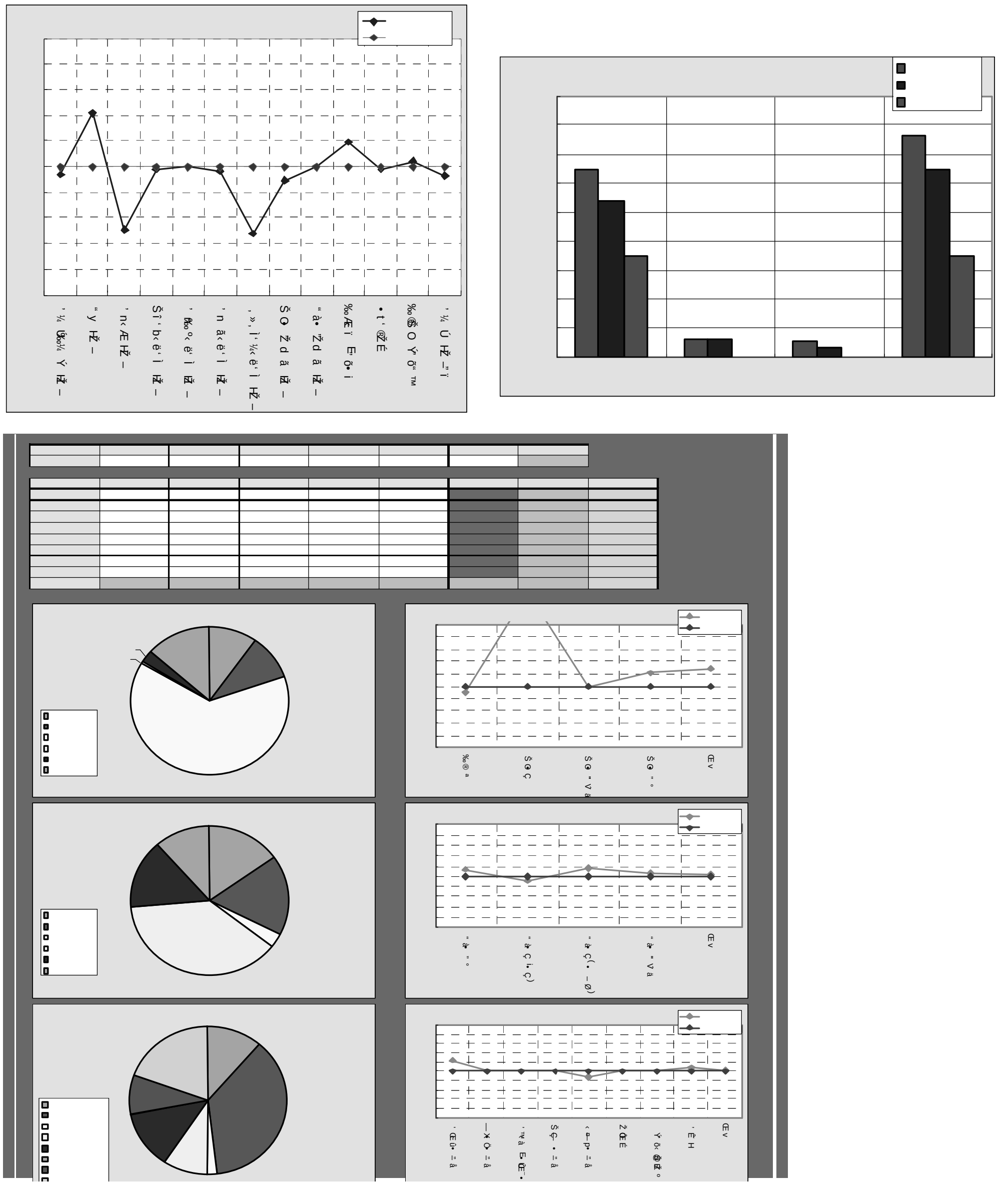


Figure 7: Sheet for cost planning (extract)

7. Conclusions

Accuracy and operational performance are satisfied on the developed cost planning system, and it is easy to apply it to change order and VE analysis. It still needs some modification towards application to real projects. These three points as follows should be discussed in future study:

1) Past real projects' data are lacks to achieve more accuracy, so it is necessary to add and modify real data.

2) The calculation process of both tool may be vague and uncertainty, so it is important to change software more easily.

3) The predicted data in design phase has the tendency not to reach quantity and cost of the real projects. Accordingly, it should be considered to increase certain amount of quantity.

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Valuation of Local Government Assets in Portugal

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Abstract

The questions regarding the elaboration of a register of the State assets, comprising both public and private domain goods, has been a major concern from national official bodies. Indeed, an updated register of State goods allows the possibility of producing, inter alia, a comprehensive national balance sheet of public assets and liabilities.

After some failed attempts throughout the last decades, a profound reform in the public financial administration has been recently implemented in Portugal. The publication of the Official Plan for Public Accounting (POCP), from which stems one for the local government level, and the Cadastre and Register of State Goods (CIBE) constitutes a fundamental step for drawing up a register and valuation of public sector assets.

The main objective of this study is to critically analyse the methodology used in the valuation of the State assets in Portugal, with a particular focus on the local government level. This is done through a review of the national legislation and the relevant international literature on this issue. In addition, a survey conducted on specific local authorities to ascertain the way they produce the balance sheet is also used in the analysis.

The results of the study show that there are measurement problems in the elaboration of the financial statements, and there is a need for a clarification in definitions, particularly in what concerns the distinction between public and private domain of State assets. The study also suggests that a better account on the State assets, particularly on construction stock, has great implications for the management, repair and maintenance of the existing physical infrastructures.

Keywords: Construction stock, Portugal, State assets, valuation

1. Introduction

The legal framework concerning the register of public sector assets, both public and private domain goods, has its origin in Portugal in the early 1980s. Legislative measures have been since then devised to set rules for Government departments and local authorities to prepare their financial reports and value their capital assets. The initial measure was the Decree-Law nº 477/80 which set standards and rules for the register of property and other assets belonging to public entities. The proposed objectives prescribed in the legal document for the existence of an up-to-date register of the State assets, were the following: to get an accurate knowledge of the public sector asset, which would provide information regarding its existence, nature, value and ownership regime; to assess the management of public sector affairs, assuring an efficient employment of the taxpayers money; to be the pillar of the political, administrative, economic, social, and intellectual life of the country; and as a basis for the elaboration of the Government balance sheet.

With the beginning of the reform in the financial administration of the public sector, in the early 1990s, several legislative initiatives have been undertaken to achieve the proposed aims. Such are: the Official Plan for Public Accounting, enacted by the Decree-Law nº 54-A/99, from which stems the Accounting Plan for Local Government (POCAL), by the Decree-Law nº 54-A/99, and the recommendations for the elaboration of the Cadastre and Register of State Goods (CIBE), enacted by the Administrative Order nº 671/2000.

These initiatives taken by the Portuguese Government are in line with the efforts made at the international level for the adoption of a more comprehensive framework for the public entities to record their holdings and prepare their financial statements according to the rules of the private sector. This exercise based in recognised national or international standards should lead to greater accountability and more efficient use of resources [1]. This surge in interest for valuing public properties is well explained by Lundstrom and Lind [2] for the case of Sweden - "…partly for ideological reasons, partly for financial reasons, there has been a growing interest in sales of public properties. The public sector has large holdings of real estate (land, special-purpose properties, housing properties and even commercial properties). Sales of real estate could raise considerable revenue…..The cut-back in public administration and public services has also led to vacancies, and an interest in selling properties that are no longer needed for their original purpose" (Lundstrom and Lind, 1996, p 32)[2]. A recent illustration, in the case of Portugal, was the purpose of the Government to sell and lease back a substantial amount of State real estate in order to keep the government accounts in conformity with the Maastricht criterion of budget deficit. However, this action was called off due to a political crisis.

In the first section, the paper presents the classification and the valuation methods used in public sectors assets in Portugal. This is done through a review of the national legislation, viewed within the context of the international regulatory framework on the issue. The next section, and based on previous research, presents the results of a survey on accounting and valuation practices in Portuguese municipalities. Finally, a concluding comment summarises the results of the study.

2. Asset classification and asset valuation in Portugal

The Portuguese legislation prescribes that all public sector assets shall be recorded, but allows that the register might include assets accounted at zero value, while the valuation of other assets may derive from either on the basis of the market value, the salvage value, or the replacement value, among others.

Local government assets, like all public sector assets, are classified according to the following categories:

- **Public domain assets**- as "Assets which, belonging to a collective public right entity, are subject by law to a special juridical regime characterised mainly for being nontradable, in order to preserve the production of their public use…"[3]. This category comprises the following assets: roads, parklands, water supply and sanitary networks, electric power networks and heritage goods.

- **Private domain assets-** as "Assets which, not being considered in public domain, are, in principle, integrated in the ownership regime established in the civil law and are, consequently, subject to the corresponding juridical trade….". [4]. Assets in this category comprise property, plant and equipment, which are not part of the public domain. This category is further divided in *non-disposable private assets,* which are those that are hold and used by the public entity to deliver its statutory services, *and disposable private assets,* which are occupied by the entity but can be transacted at any time.

As stated earlier, the Portuguese legislation stipulates that all type of assets administered by local authorities shall be registered. Thus, apart from the disclosure and classification, the public entity shall value all its assets, both public and private domain goods, in order to elaborate a comprehensive register of all assets to be accounted in the balance sheet and other financial reports. In the case of fixed assets, the POCAL prescribes that this exercise shall also comprise public sector assets in the administrative sphere of the entity, and even those that are in financial leasing regime.

According to the POCAL and CIBE, the production cost or acquisition cost approaches are used as a general rule in the valuation of local authority assets (Figure1). In the cases these valuation methods cannot be applied, or do not provide an accurate picture of the financial and patrimonial situation of the institution, other valuation methods should be used (present value calculated through the discounted cash-flow method, sales comparison method and replacement cost method). If it is not possible at all to value an asset, the notes in the financial statements must indicate which kind of assets is not accounted for, as well as the respective explanation. In this case, namely for historical and cultural goods, they must be recorded and accounted for at zero value, unless they are insured. In the latter situation the insurance value is the basis for the valuation.

The method used in Portugal for quantifying depreciation of public sector assets is the percentage depreciation method, according to the depreciation rates prescribed in the CIBE classifier, according to each type of goods.

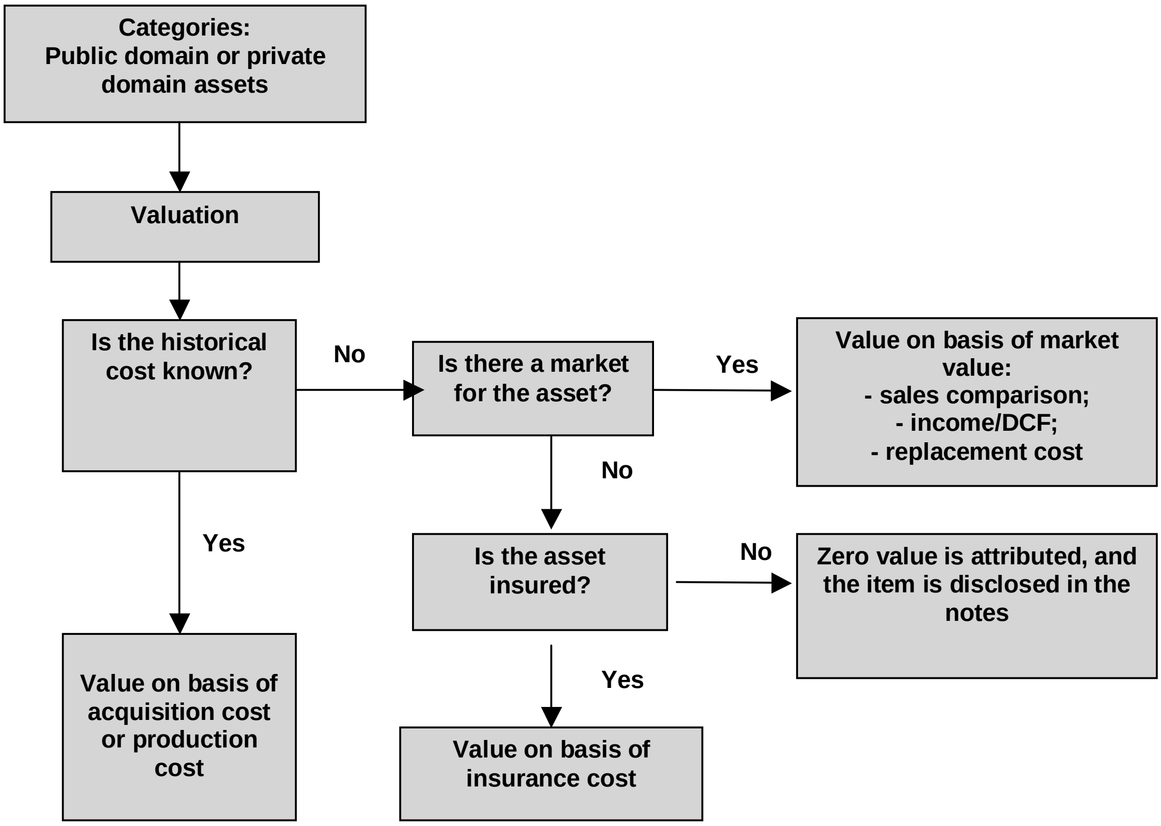

Figure 1: Asset valuation in Portugal

At the international level, the IPSAS (International Public Sector Accounting Standard) 17 [5] prescribes that it is an option for the public sector entities to recognize in their balance the public domain goods that satisfy the recognition criteria of a tangible fixed asset. However, if they do opt for recognition they must follow the disclosure requirements, but not the valuation requirements. According to IPSAS 17 §13 and IAS (International Accounting Standard) 16 §8 [6], a good should be recognised as a fixed asset when two conditions are cumulatively met:

- It is probable that future economic benefits or service potential associated with the asset will flow to the entity; and
- The cost or fair value of the asset to the entity can be measured reliably.

However, the valuation of public sector assets has been subject to many controversies. Several writers [7, 8] have questioned the opportunity and relevance of the register and subsequent valuation of certain types of assets, namely heritage assets, military assets and public goods, which are rarely, if ever, transacted. Furthermore, there are differing points of view and debates, particularly in respect of definition and valuation practices (Pallot, 1997), cited in [9].

In order to place the Portuguese classification and valuation of public sector assets into a comparative perspective, the following categorisation and classification of public sector properties in United Kingdom is presented, according to the RICS *Red Book* (Connellan, 1997, p 216)[10]*:*

- **Non-operational assets**: as "Fixed assets held by a local authority but not directly occupied, used or consumed in the delivery or services. Examples …are investment properties and assets that surplus to requirements…."
- **Operational assets:** as "Fixed assets held and occupied, used or consumed by the local authority in the direct delivery of those services for which is has either a statutory or discretionary responsibility".
- **Community assets**: as "Assets that the local authority intends to hold in perpetuity, that have no determinable useful life, and that may have restrictions on their disposal…"
- **Infrastructure assets**: as "Fixed assets which are inalienable assets, expenditure on which is recoverable only by continued use of asset created. Examples are …highways and footpaths".

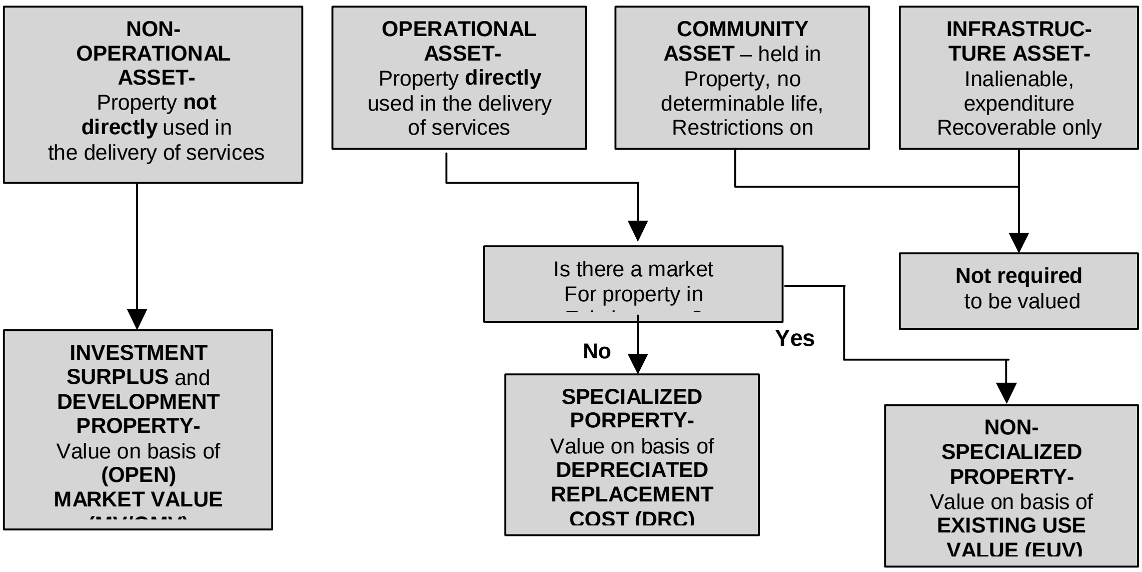

Figure 2: Classification and valuation treatment of assets in UK Source: [10]

Thus, there is no significant difference between the Portuguese and UK classifications of Public sector assets except that the UK categories *infrastructure assets* and *community assets*, taken together, correspond to the Portuguese *public domain assets.* Regarding the valuation practices in the public sector, it can be seen (Figs. 1 and 2) that whereas in Portugal all kind of assets shall be valued, in UK there are some categories (community assets and infrastructure assets), which are not required to be valued.

3. A Survey on the Practice of Local Authority Accounting in Portugal

3.1 Method of Data Collection

As stated before, this section is based on a previous research [11], which was undertaken with twelve local authorities of a district in the north-eastern region of Portugal. The study consisted of structured interviews with representatives of the municipalities (city mayors and/or valuation officers) and was aimed to get acquainted about the way local authorities did register and value their fixed assets, as wells as to get a general view of how they did comply with the new accounting practices. The objective of those face-to-face interviews was to assess the criteria and methods used in each phase of the accounting process (classification, valuation and accounting) and to ascertain the main problems and difficulties they faced in their statutory responsibilities. A summary of the results is provided below.

The results of the initial study shows that, despite local governments are required by law to record their holding of property and other assets since the financial year 2000, nine (75%) of these entities had not undertaken at that time (2002) the register and valuation of none of their assets. The municipalities that had already undertaken the exercise used the valuation criteria prescribed in the POCAL and RICB (Regulation of Cadastre and Register of Local Authority Goods), most often on the basis of the acquisition cost or production cost whenever support documents existed. Other valuation criteria based on the market value approach were also used, namely in roads, public lighting, water treatment and water supply networks. These criteria, depending on the type of goods, are based on the fair value concept and cost replacement value, and are statutorily established by the *Valuation Commissions* whose members are designated by the City Councils. Out of the twelve local authorities analysed, only one had at the time an approved RICP, which limits to a simple transcription of the valuation criteria prescribed in the POCAL, and disregards the situations in which a valuation method should be used in detriment of others.

In order to complement and update the data obtained in the earlier study, a letter was sent in 2004 to the same local government representatives to provide the financial statements of the year 2003, which comprised, among others, the following documents: the annual budget of the entities as well as its execution, the balance sheet at December 31, 2003, and the notes to the balance sheet. Only six (50%) of the local authorities responded to the request.

In the methodology adopted in the study, the data were collected on the basis of the figures and information expressed in the aforesaid documents, namely the expenditure budget control map, the balance sheet and the notes.

3.2 Results of the Survey

Classification and Valuation of Assets

Regarding the classification of assets, the analysis of the data indicates that all municipalities that responded to the request followed the legislation into force. It was, however, emphasised that there were difficulties in distinguishing between private domain and public domain assets, and often in establishing the ownership rights (whether local or central government) over the same assets. Another difficulty concerning all local governments analysed had to do with the lack of records and project designs, namely water and sanitary system designs.

With respect to the valuation of the assets, the data analysed show that 66.67% of the municipalities did not provide the criteria used in the calculation of the fixed assets. Only two, 33.33%, of the municipalities provided in the notes the criteria used in the valuation - the acquisition cost or production cost as a general rule. One of these two entities attributed a zero value to the public domain assets existing until the beginning of 2002, due to varied problems: lack of historical records; difficulty in establishing the ownership of the assets; and the lack of objective valuation criteria pre-established by the competent authorities. The other municipality, in the initial register, used other valuation criteria other than the production cost or acquisition cost for a set of public domain assets, for which information on the acquisition cost was not available. It is assumed that the valuation methods might have been either the replacement value or on the basis of market value approach. The choice of the valuation method was established by an expert commission. With the data available, it was not possible to ascertain the significance of each valuation method in the measurement of total fixed assets of the entities. As an example, for the case of the U K, the following results are presented regarding the valuation methods used in a set of local authorities: Replacement cost – 33%; Sales comparison – 32%; Income/ DCF – 20%; and Other – 15% [1].

For the quantification of depreciation, the valuation officers of the local authorities used the percentage depreciation method, following the prescriptions in the POCAL. As stated earlier, the annual depreciation is calculated on the basis of the depreciation rate defined in the CIBE classifier.

The Clout of Public Domain Assets and Total Fixed Assets

Drawn from the balance sheet of the local authorities, Table 1 presents the share of public domain assets and total fixed assets in the total balance of the entities. It can be seen that the share of the public domain assets varies widely across municipalities - from 4.6 % to 61.6%. This situation is explained by the fact that, as already noted, one municipality accounted at zero value all existing public domain assets in the reference year 2002. In some municipalities, the figures concerning the same category of assets correspond mostly to work in progress.

Table 1- Clout of Public Domain Assets and Fixed Assets in Total Asset

Municipality	***Public Domain Assets/ Total Asset***	***Total Fixed Assets/ Total Asset***	***Total Asset* (€)**
A	22.2%	83.6%	7,751,826
B	4.6%	92.4%	4,249,714
C	26.2%	98.6%	35,350,269
D	22.2%	94.1%	22,801,643
E	33.9%	96.2%	2,292,204
F	61.6%	97.9%	90,438,465

Source: Financial Reports from Local Authorities (2004)

The majority of the municipalities, which have undertaken the valuation of their public domain assets, claimed that there is a lack of trained valuation officers, which would allow them a thorough classification and measurement of their assets. This problem gets worse for the small municipalities are precisely those that present a lesser share of fixed assets in total assets. However, when asked about the importance of the disclosure and valuation of public domain assets, 90% of the interviewees found that that was very important for the majority of the expenditure of the municipalities referred to the production and management of public domain goods.

The picture that emerges from Table 1 (as wells other data from the financial statements) suggests that it is not possible to elaborate a balance sheet that provides an accurate picture of the value of fixed capital of a municipality, so as to allow a comparison between municipalities. In fact, it appears to be a daunting task to draw a comparison between two municipalities, in which one has a total asset valued at € 2,000,000 and the other a total asset of € 35,000,000, when, apparently, the differences between them are not much significant, both in terms of population and territorial dimension, and in terms of the amount of physical infrastructure. In an earlier study, it was pointed out that identical assets were valued trough different methods, for there are no clear rules about when and which methods to be used in each category of assets. This fact was, according tom that study, the main problem for the municipalities to comply with their legal accounting responsibilities [11].

Table 1 also indicates that the value of fixed assets represents, in all but one case, more than 90% of total asset. The share of other components of the total asset is almost residual. If we take into account that some municipalities did not value all of their fixed assets, the clout of this indicator will, in a further accounting exercise, become even higher.

Table2: Share of Capital Expenditure and R & M Expenditure in Total Budget 2003)

Municipality	***Capital Expenditure / Total Budget***	***R & M Expenditure/ Total Budget***
A	55.04%	0.19%
B	39.43%	0.73%
C	49.57%	081%
D	47.92%	0,61%
E	29.03%	0.81%
F	60.53%	0.24%

Source: *Financial Reports from Local Authorities (2004)*

Table 2 presents the share of Capital expenditure and R&M expenditure in the total budget of the municipalities in 2003. It can be seen that the former represented bout 50% of total budget and the share of R& M was insignificant. The latter is explained by the fact that repair and maintenance is treated as current expenditures in line with the Portuguese *National Accounts*. Thus, the expenditure on capital comprises only new construction and equipment and major repairs. Data from the financial reports indicates that construction (building and civil engineering) represents the major part of the capital expenditure of the municipalities. This, added to the fact that most of existing fixed capital is comprised of construction stock, is a significant aspect that reflects the importance of property in the economy of the municipalities.

According to a recent study undertaken by a CIB (International Council for Research and Innovation in Building and Construction) project group, after allowing for cyclical fluctuations, the general trend in construction activity in very developed countries is for construction activity to be in a relative decline [12]. The study also reveals that a noticeable feature of the activity of the industry in these countries has been the change in the *new build: repair and maintenance* mix over the last few decades. Repair and maintenance now accounts for almost a half of the industry’s activity, as stock management has become a relatively much more important aspect, particularly in post-industrial economies. Although the share of R& M in total construction is about 7% (this figure is certainly underreported), it is assumed that the development pattern of the construction industry in Portugal will follow in the medium to long term the general pattern of the highly industrial countries [13]. As fair as local authorities are concerned, there has been a trend in shifting responsibilities from central to local government with respect to the management of infrastructural assets. The repair and management of this huge stock will become a central aspect in the activities of the municipalities.

4. Conclusion

This paper has presented an analysis on the criteria and methods of classification and valuation of public sector assets in Portugal, with a particular focus on local authorities. The results of the study have shown that despite the municipalities are required by law to record and value their holdings of property and other fixed assets since the financial year 2000, some of the entities analysed in the study did not comply with their legal responsibilities. The entities that did undertook the exercise emphasised definitions problems in what concern the distinction between public and private domain goods, and lack of a comprehensive framework to the valuation practice in the public sector. Though the latter aspect is also an international concern, the problem is aggravated in Portugal due to a lack of clear rules for the classification and valuation of public assets.

The analysis has also shown that building (both public domain and private domain buildings) and civil engineering infrastructures have a significant impact on the economy of the municipalities, both in terms of existing capital stock and in terms of annual capital expenditure. Taking into account that the trend is the increase in the repair and management of existing in stock to the detriment of new build, this aspect may have implications for the management of the activities of local authorities, and certainly for all public policy in the years to come.

The sample analysed in this study is very small and may not provide a true picture of the valuation and accounting practices in Portuguese local authorities. Anecdotic evidence, however, suggests that, allowing for <major metropolitan areas, some patterns that were outlined still hold for the majority of the local authorities. Of course, the sample should be broadened and the underlying issues should merit a more thorough investigation. This is the subject for further development.

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Abdul Samad (Sami) Kazi

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Preface

In an industry that is dominated by one-of-a-kind projects involving competence sharing between different organisational entities, and thin profit margins, a key challenge in the new global economy is to ensure delivery of projects that are on time, within the cost limits, of high levels of quality, sustainable, and provide value to the customer. All this, while ensuring that contractors remain profitable without raising project costs. This calls for systemic innovation in the management of construction projects and processes that takes into consideration all relevant aspects and stakeholders of the complete product and service lifecycle [1, 2 and 3].

The Project Management Body of Knowledge (PMBOK) [4] provides one perspective to the effective management of projects and processes. Understanding the unique characteristics of the construction industry, a special construction extension to the PMBOK was released [5]. It is primarily based on a set of guidelines for different functional areas for the management of processes within projects. Concerns have however been raised about its completeness and applicability[1]. In fact, Koskela and Howell [6] challenged the validity of the underlying theory of project management. If not more, this at least presents the impetus to explore project management from a different set of perspectives. As an example, one could consider management of processes and projects from the perspective of information flows and contract networks (figure 1) within inter-enterprise project environments such as construction [7]. This simple illustration is an indicator of some of the underlying problems in the management of processes and projects within the construction sector.

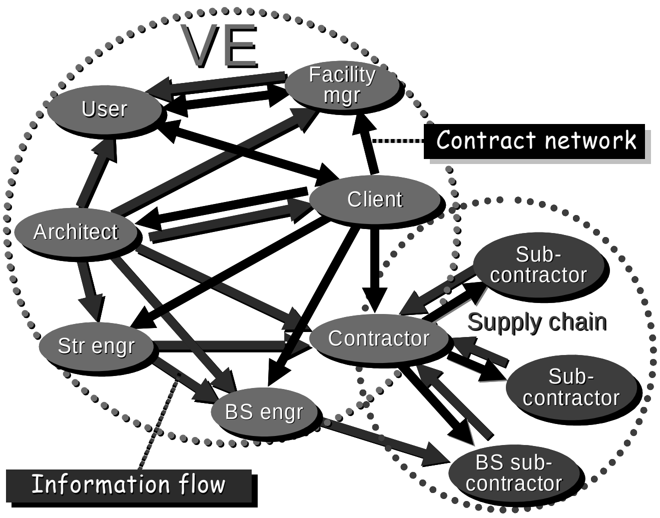

Figure 1: Information flows and contract networks within construction projects

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[1] See the review of [4] by Max Wideman at http://www.maxwideman.com/papers/pmbok3/intro.htm

The challenge of systemic innovation in the management of construction projects and processes has been taken up in this book. Contributions and experiences from Australia, Brazil, China, Croatia, Finland, Norway, Saudi Arabia, Sweden, Taiwan, The Netherlands, United Kingdom, and USA unveil how systemic innovation is being used to manage projects, product processes and control, productivity and performance improvement, product delivery systems and contractual practices, and risk management.

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Section I

Managing Projects – Methods and Practices

Briefing for Arts Construction Projects: Capturing the Needs of Arts Clients

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Abstract

More than £ 1 billion of public funding has been spent by the Arts Council of England (ACE) Lottery Fund on the arts, mainly on building constructions. However, it is evident that many of these projects were completed over the budgeted amount and scheduled time. Among various phases in the procurement, the briefing process has been considered critical to successful construction and yet problematic in its effectiveness. Whilst the briefing process in construction projects has been generally claimed to 'limit' the client in further stages, the briefing process for the Arts is required to translate the spatial needs of the so-called 'artistic vision' into a building. Thus, the briefing process in the Arts project is expected to accommodate the needs and requirements of the Arts clients that may be unique and dynamically change over time. The research aims to elucidate the most appropriate briefing process or processes that delivers a 'better' environment for the Arts. The methodology applied in this investigation is literature synthesis followed by case study. Case historical analyses of six case studies will be performed with one of the cases as a pilot case. In further phases, in-depths interviews to the key persons of the six cases will be conducted to complement the case historical analyses. Findings from the literature synthesis of generic briefing and the proposed research methodology are brought together in this paper and major issues highlighted.

Keywords: Arts projects, briefing, client needs and requirements

1. Introduction

A distinctive characteristic of most of the Arts buildings is the many sources of funds there may be for a single project, acquired from a broad base of funding sources. These sources of funds may affect the phasing of the building programme or incorporation of special facilities [1]. Various sources of funding are available for the Arts. The funding is for promoting the Arts, subsidising Arts productions, supporting Arts projects, as well as capital projects [2]. In addition to one-off grants from local and central government, tourist authority, European Union, Development Corporation, and Regional Arts Boards, there are loans from local governments, banks and financial institutions [1]. However, local governments' funding is typically through providing buildings and revenue support to Arts organisations. Private sector is another source of funding [2]. Government's funding the Arts has been channelled through several non-governmental organizations [1, 2], the largest of which is the Arts Council.

More than £ 1 billion has been spent by the Arts Council of England (ACE) Lottery Fund on the Arts building construction. However, a significant proportion has been considered problematic. The National Audit Office (NAO) reports many of the reviewed projects were experiencing cost overruns and delays [3, 4]. The CIB (1997) [5] has published a set of documents designed to improve the quality, effectiveness and efficiency of construction projects with particular emphasis on the briefing process since the outcome of any project is considered relying on the quality of the briefing. Kelly et al. (1993) [6] recommended a thorough briefing in order to develop a building with better value for money. Whilst the best value for money is considered achieved when quality is maximised for a given cost, cost minimised for a given quality or some optimal compromise between the two [7], it has been generally accepted that quality is defined in term of punctual deliver of the completed facility, functional utility, social and legal acceptability and aesthetics [6]. Hence, the success of the briefing process can be associated with the success of the project deliveries. Despite the fact that the briefing process has been extensively researched, building for the Arts are considered complex and unique due to the strict requirement to meet exacting technical requirements and also necessity to respond to various and sometimes conflicting demands of artists and performers, managerial staff, funding organizations, and the general public [1, 2]. Hence, an alternative approach may be required to apply the generic concept of briefing 'good practices' into the performing of Arts building projects.

In light of this, the research is set to investigate the most appropriate briefing practices to enable a 'better' environment in order to deliver excellent buildings for the performing Arts. This is to be achieved by investigating and analysing selected buildings for the performing Arts (i.e. case studies) that have been briefed, designed and procured in the relatively recent past. The use of case study method allows the research to retain the holistic and meaningful characteristics of real-life events [8]. In-depths interviews to the key persons of the studied cases will be conducted to complement the case historical analysis. The outcome is expected to provide valuable new insights and guidance for the Arts community to engage in a capital project to receive the best value for money in providing spaces for the performing Arts.

2. Construction Briefing

The common understanding of the briefing process in the UK (also known as architectural programming in the USA terminology) is generally about capturing information and ideas from Clients. This process results in the development of the brief and is followed by understanding the captured information and ideas, proposing and explaining to the Client all the alternatives and issues related to their requirements (e.g. risks and constrains), justifying and getting approval of the Client for certain alternative or scheme, followed by the translation to the designers' language to form the base for further stages. Despite this common understanding, various formal definitions of the briefing process exist [5, 9, 10, 11, 12]. Complementing the definitions, researchers have also provided their own explanations in understanding the process. Kamara et al. (1999) [13] defined the briefing process as the process of formulating and developing the brief. Barrett and Stanley (1999) [14] perceived briefing process as a process of innovation in which ideas are created and implemented and continued to inform all the technical work throughout the project. In the field of building design management, Grey *et al*. (1994) [15] regarded the briefing process as providing a clear means for proceeding and communicating the design tasks and objectives across the interfaces between one stage and the next. Hyams (2001) [16] described briefing as a process that is distinct and yet integral to the design process, avoiding wilfulness and giving client they have decided, need and want. From the various definitions and views on briefing discussed, three central themes were observed to enable further discussion, namely the role of the parties in the briefing process, the extent of the briefing process in regards to the construction stages, and the objective of the briefing process.

2.1 The Role of the Parties

The briefing process has been considered as a team effort between the participants from both the client group and the consultant team [17]. Further break down of the parties were provided by various research [16, 18, 19] into four general groups, namely the *Clients*, the *Building Users*, the *Regulatory Agencies* (including public interest parties), and the *Consultants*. However, the term *Client* reflects a singular term often intended to encapsulate a complex consortium of stakeholders whose opinions and factual requirements need to be consolidated into a singular consensus view [20]. Hence, in the subsequent discussion, the term *Client* is considered encompassing both the client organisations and the *Building Users* (i.e. end users).

Various definitions and views of the briefing process prescribed the role of the parties, particularly the Client and the Consultant. BSRIA (1990) [11] regards briefing as a process by which the designer receives all information to form the basis for detailed design involving the extraction of information from clients regarding their requirements and expectations. CIB (1997) [5] explicitly mentioned that the Clients should inform other of their needs, aspiration and desires, either formally or informally implying that the Client is responsible to make clear the requirements to the consulting team. This stand is supported by BRE (1987) [18], describing clearly that the Client is responsible for the briefing process by the means of preparing and providing enough information. Sports Council (1994) [21] prescribed the Client's body to be responsible in determining what is and its local community need or want. The purpose of briefing process is for the Clients to communicate their needs and objectives in initiating the project [22]. Clients must clearly express project objectives in terms of building requirements, costs and time budgets [23]. The findings from a study by Cherns and Bryant (1984) [24] have demonstrated the importance of this Client's role in a briefing process.

In contrast to the views above, British Standards (1995) [25] views the briefing process as a process of identifying and analysing the needs, aims and constraints of the client. RIBA (1967) [9] prescribed that the briefing process is intended to prepare general outlines and plan future action by setting up the Client organisation for briefing and also to provide the Client with an appraisal and recommendations. These views shifted the responsibility from the Client to the Consultant. The Consultant is no longer perceived as a passive party relying on the Client to provide information, but rather as an active party to identify, capture, and analyse the Client's requirements and needs. Several researchers were even promoting further analysis of the Client's business processes in order to improve the briefing process and to understand the way in which any proposed built solution would impact upon these business processes [6, 26, 27].

Various other views present a reconciliation of these two views. Murray (1996) [28] asserted that the Client has direct responsibility for the project development in the briefing process with a 'symbiotic' relationship (i.e. a reciprocal interaction) to achieve more effective briefing. CIRIA (1995) [12] views the briefing process as a collaborative and evolutionary process between the Clients and their advisors. BSRIA (1998) [11] perceived the briefing process as an iterative process involving regular feedback from the Client, advisers design team, and end users. Thus, briefing is a collective process involving both the Client's and the Consultant's contributions. The allocation of responsibility bearing on the briefing process is associated with the experience of the Client. Gameson (1996) [29] asserted that the level of briefing interaction between the Client and the Consultants varies considerably depending on two factors, one of which is the Client's previous experience of building construction. The experience of the Clients has been reported to influence the potential of having changes on the pre-construction and construction periods [30, 31]. The more experienced the Client is, the less necessary for the Consultant to identify, capture, and analyse the Clients' requirements and needs.

2.2 The Extent of the Briefing Process

Kelly et al. (1993) [6] and CIB (1997) [5] recommend two stages of the briefing process, known as the strategic briefing and the project briefing. The strategic briefing comprises a strategic review of the Client's organisational needs and further specified as an independent stage to set up the project strategy for the Client's business needs and objectives prior to any formal design and construction action. The latter is more tactical in nature and is primarily concerned with issues of performance specification. A detailed chart of briefing process has also been provided by CIB (1997) [5]. In this chart, the strategic briefing is subdivided into two key stages (i.e. *Getting Started* and *Defining the Project*). Each stage is defined as a set of necessary activities in order to produce a strategic brief or project execution plan. Gray *et al*. (1994) [15] asserted that the briefing stage should provide a clear means for proceeding and communicating the design tasks and objectives across the interfaces between one stage and the next. These views are inline with the view from RIBA (1967) [9] mentioning that the briefing process encompasses the inception and the feasibility phases of their *Architect's Plan of Works*.

However, RIBA (1973) [10] expanded this view on briefing process later on to include the outline proposal and scheme design phases of the *Architect's Plan of Works* and freeze the content of the brief for the subsequent phases. Whilst accepting many criticisms for freezing the brief after the scheme design phase, this expansion of the briefing process demonstrated a significant shift from viewing the briefing process as a 'one-off' event to the one that encompass other phases in the construction process. The briefing process is now considered to encompass both the strategic and project briefing. This shift of paradigm can be addressed to the limitation of the 'one-off' view which is not allowing options to be kept open to reflect the changing circumstances during the development of the project [32]. Atkin and Flanagan (1995) [26] proposed an eight-stages briefing process which overlaps the briefing process with the design process. Furthermore, CIRIA (1995) [12] considers the briefing process as a process after the feasibility stage that encompass programme for the design and construction work, and control procedure to guide the progress of the project within the time and budget. British Standards (1995) [25] considers a brief as a working document which specifies at any point in time the needs and aims, resources of the Client and user, the context of the project and any appropriate design requirements. Barrett and Stanley (1999) [14] considered briefing process as a process that starts early and continues to inform all the technical work throughout the project.

In the facility management, Preiser (1993) [33] identified the importance of developing a database of previous projects to learn from successes and failures in building performance to future buildings, thus promoting the importance of the Post Occupancy Evaluation (POE). In line with this, the function of briefing is extended further to the post project stage involving a constant feedback loop [5, 32, 34, 35]. Briefing is regarded as a continuous and cyclical process in order to evaluate the project and feedback to new projects (includes the POE process). Nutt (1993) [35] proposes a *total briefing cycle* in the facility management. The focus of this approach is on extending briefing into a cycle feedback information system, in which the brief is regarded as a periodic modification and improvement of facilities for a long-term consideration. The concept of POE is employed into *a total cycle* of the briefing process. Reinforcing the *total cycle* view of the briefing process, Blyth and Worthington (2001) [32] proposed a framework associated with a series of activities to identify various types of briefs that recorded the entire project development. The briefs are then guiding the development of the design process in sequence including POE. The shift from viewing the briefing process as a part of an early stage into an integrated part of the entire construction and management process encompassing the POE has been considered as the current trend [36].

2.3 The Objective of the Briefing Process

Generally, the objective of the briefing process is to develop the brief which encompasses the Client needs and requirements to enable the designer fulfilling those needs and requirements. Several views [37, 38, 39] have stimulated an ethos shift from merely fulfilling the needs and requirements specified in the briefing into pursuing for the Client's satisfaction. Clients are most likely to be satisfied when the final product matches or exceeds their expectations [40]. Research on the construction process has suggested the significant role of briefing in delivering client satisfaction [41] underpinned by the underlying assumption that an improved briefing process can deliver a better product to the Client [42]. Driven by this redefined objective (i.e. to satisfy the Client), further research emerged resulting in various frameworks and interesting findings. The Innovative Manufacturing Initiative/IMI (a joint research council activity funded by Engineering and Physical Sciences Research Council/EPSRC, Economic and Social Research Council/ESRC and Biotechnology and Biological Sciences Research Council/BBSRC) targeted the construction sector with a number of programmes. One of these programmes is the Link IDAC (Integration in Design and Construction) programme, co-funded by the Department of Environment Transport and Regions (DETR). Many of the projects are concerned with briefing and design or general information capture from the Client in construction such as *Managing the brief as a process of innovation* (Link IDAC 88) by the University of Salford, *Design information methodology and tools for the management of detailed building design* (Link IDAC 100) by the Loughborough University, *A client's project definition tool* (Link IDAC 11) by the University of Reading, *Decision making tools for controlled innovation in construction* (Link IDAC 82) by the Cranfield University, *Building a high value construction environment* (Link IDAC 229) by the London School of economics and the Leeds Metropolitan University, *The proposed requirements/conceptual design project* (Link IDAC 5/044) by the Loughborough University and the Strathclyde University, *The proposed IMI Process Protocol* - Level 2 project by the University of Salford and the Loughborough University, and *Learning from Experience: Applying Systematic Feedback to Improve the Briefing Process in Construction (LEAF)* by the University of Sheffield.

Leaman (2002) [43] proposes a detailed matrix (known as 'targeted briefing') method to conduct the briefing service to the Client. This method assumes that the Client's requirement can be identified thoroughly by fulfilling targeted headings of the brief format. Various other researchers prescribed models based on the matrix framework [34, 44, 45, 46]. This matrix framework has been generally considered an advancement of the more traditional checklists as proposed by Salisbury (1998) [47] or Hyams (2001) [16]. Moreover, Kamara *et al*. (2002) [48] proposes the *Client Requirements Processing Model* (CRPM) focusing on a solution-neutral formulation of client requirements. Another research by Fisher *et al* (2000) [49] proposed the *Client Project Definition Tool* (CPDT) with a focus on capturing user requirements for buildings. These models represent the implementation of methods applied in manufacturing industries for reconciling costumer's need and business objectives in the product development into construction briefing process, widely known as the Quality Function Deployment (QFD).

3. Evaluation of Briefing in Arts Construction Projects: the Research Methodology

This research project aims to assess the briefing process in the performing Arts construction projects. The measurable objectives of the research is to investigate and analyse thoroughly how selected buildings for the performing arts have been briefed, designed and procured in the relatively recent past. This is expected to lead to the identification and the development of the successful ‘good practice’ (applicable to all stakeholders) exploiting the particular skills and abilities in the Arts for creating and communicating ideas and 'visions'. This is to be followed by a broad dissemination of the new understanding in ways which are intelligible and engaging, exploiting media familiar to the Arts community in the use of the moving image, performance, narrative and scenario building in addition to more conventional outputs.

In order to achieve the aims and objectives of the research, the generic overview of briefing process in the construction projects has been reviewed. In-line with this, subsequent phase discusses the evaluation of the briefing process in the Arts construction projects. As a starting point, the evaluation of the briefing process in the Arts construction projects can be viewed from three different perspectives explained in the previous section, namely the role of the parties, the extent of the briefing process, and the objective of the briefing process. As highlighted earlier, the study intends to investigate and analyse selected buildings for the performing Arts that have been briefed, designed and procured in the relatively recent past. Hence, the selected strategy is multiple case study and grounded theory methodology in order to ensure an in-depth interaction between the researchers and the participants of the briefing process and formulation of an interpretation of the encounters. The richness of descriptions will be organized to develop a new understanding of briefing for the arts buildings.

Grounded theory is a general methodology to develop theory that is grounded in systematically gathered and analysed data aiming to develop theory through continuous interplay between analysis and data collection [50, 51, 52]. Theories emerging from grounded theory methodology are always traceable to their original data source, and are always fluid due to the emphasis on interaction among participants, temporality and process. This faithfulness of theory to the actual data offers usefulness in practice [50]. In acknowledging the multiple perspectives of a diverse range of existing theories, it is considered important to combine the theory emerging from the grounded theory methodology with the existing ones, while keeping the connection with the actual data [14]. Case studies are empirical inquiries investigating phenomena in their natural settings [8]. In a multiple case study strategy, the cases are studied in their real-life contexts with reliance on multiple sources of evidence and with a purpose to generalise to theory, which is emphasized in the research design phase [52]. Case studies are essential for description [53, 54] and therefore useful with grounded theory. The multiple case study aims to identify patterns using replication logic within and among cases, which can be either similar (literal replication) or contrary but for predictable reasons (theoretical replication). Consequently, one of the strategies is replication seeking, in which repeating patterns (either similar or contrary) are presented. The other strategy is pattern matching, in which findings are compared across cases or to a theoretical proposition to reveal patterns [8].

Two techniques of data collection are intended for use in this research, namely interviews and archival research. These two techniques are expected to inform each other at different stages of the study. Interview was set as the primary method of data collection, since individuals are considered the valuable sources of particular information. Interviews allow both parties to explore the meaning of the questions and answers involved. The interviewees were targeted and selected from different stakeholder groups to provide multiple perspectives and in-depth understanding of different issues in the briefing process. Archival research involves locating and assessing primary data or information in archives pertinent to the topic of the study [55]. In this study, the major archives resource is the documentation from the design teams. Another source considered is the building management, such as the management boards' files.

Being the interplay phase between analysis and data collection, coding for analysis is integrated to data collection procedure. One option of establishing coding frames is to follow the sequence of open coding, axial coding and selective coding [56]. Open coding involves organising the data into categories and sub-categories. Axial coding puts the data back together in a new way through establishing the relationships between these categories and sub-categories [57]. Selective coding involves conceptualising the relationships among categories for theory building [52]. Selective coding also includes comparing the potential theoretical frameworks emerging from analysis to the existing theories in the literature [14].

Following the finalisation of the cases and respondents selection, the broad framework for interview questions are prepared based on the literature review and pre-pilot interviews. The pre-pilot interviews are conducted prior to the pilot case with respondents involved in briefing and design processes for a performing arts building other than the cases selected for this case studies and aims is to complement and clarify the topics identified in the literature review. The pilot case is intended to provide guidance in evaluating the interview questions, the types of archives to investigate, and the coding frame at this stage of analysis. The pilot case will be started after clarifying the broad framework for interview questions. Upon completion of interviews and archival research of the pilot case, initial stage (open coding) of the analysis will be carried out. In this phase literature will be revisited to provide important insights in preparing the coding frame. The three perspectives identified (i.e. the role of the parties, the extent of the briefing process, and the objective of the briefing process) are intended to assist in understanding of the briefing processes in the performing Arts construction projects. For the remaining five cases, similar analysis procedure follows. At the cross-case analysis stage (axial coding), the coding frames of each case will be compared. The final theory building will be based on pattern matching among the cases and revisiting the literature to compare the emerging theoretical frameworks to the existing ones in the literature (selective coding). Within the scheme of multiple case study strategy, performing arts buildings are selected to ensure variety (theoretical sampling) and accessibility of the resources (purposive sampling). The variety criteria of the selected cases are based on the type of the client, number of spaces in the project, type of the project (new-build or refurbishment), funding source, budget size, audience type, and program type. The selection of cases also considers the completion (within the last five years) and the accessibility to archives and interviewees. At the present stage, six cases have been identified and targeted in order to fulfil the desired criteria. The selected case studies include two arts centres, three theatres, and one drama studio. The case studies represents both newly-built and refurbishments. The initial budget size of the cases ranges from £ 4.8 millions to £106 million. At the moment of preparing this paper, many of the interviewee targets from the selected cases have been contacted and requested for cooperation.

In order to summarise the research methodology designed to evaluate the briefing process in the performing Arts building projects discussed above, a diagram is provided in the Figure 1.

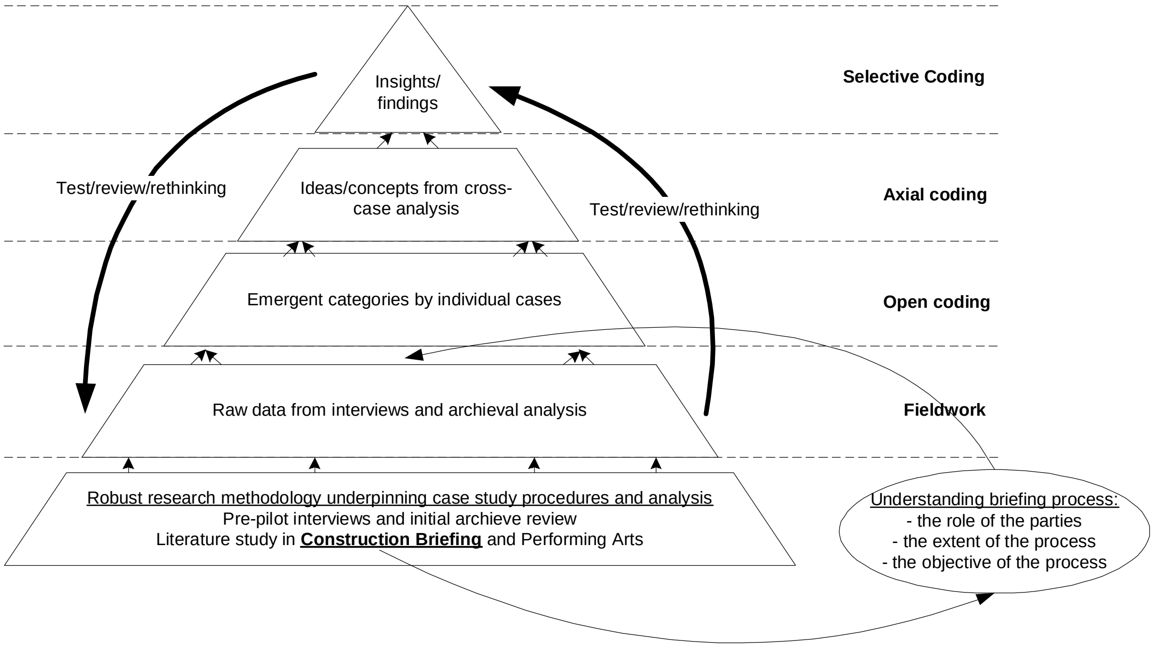

Figure 1. Research methodology to evaluate briefing process in performing Arts construction projects (adapted from Barrett and Stanley (1996) [14]).

4. Conclusion and Further Research

This paper has explained an on-going research project aimed to assess role of the briefing process in providing a 'better' environment for the performing Arts projects. The measurable objectives of the research is to investigate and analyse thoroughly how selected buildings for the performing arts have been briefed, designed and procured in the relatively recent past. This is expected to lead to the identification and the development of the successful 'good practice' (applicable to all stakeholders) exploiting the particular skills and abilities in the Arts for creating and communicating ideas and 'visions'. This is to be followed by a broad dissemination of the new understanding in ways which are intelligible and engaging, exploiting media familiar to the Arts community in the use of the moving image, performance, narrative and scenario building in addition to more conventional outputs.

The briefing process has been reviewed in detail in this paper. Various views on the briefing process have been presented by providing in-depth discussion on emerging three central themes, namely the role of the parties in briefing process, the extent of the briefing process, and the objective of briefing process. In discussing the role of the parties in briefing process, different opinions on allocating the responsibility of the briefing process became evident. The allocation of responsibility of such a process was then found influenced by the experience of the Clients. The more experience the Clients, the higher their own ability to ensure that the Consultants understand their needs and requirements and the Consultants are then responsible to accommodate the needs and requirements into their design. The discussion on the extent of the briefing process revealed differences on the implementation of the briefing process on the construction stages. Some views consider the briefing process as a 'one-off' event that performed in the pre-project stage, typically prior to the design phase to establish a 'frozen' brief. However, the review of the literature has also revealed the shift from this view into the one that consider the expansion of the briefing process into the whole life cycle of the project. In discussing the objective of the briefing process, the shift of working ethos from merely fulfilling the Clients' needs and requirements into the one that embrace the Client's satisfaction was identified. Various research were attempting to achieve such redefined objective including the implementation of methods applied in manufacturing industries for reconciling costumer's need and business objectives in the product development into construction briefing process.

Furthermore, the research methodology has also been explained in detail. The use of multiple case study strategy enables the study of each building's briefing process in detail. Interviews are expected to enhance the thoroughness of the study by providing access to exploring actual experiences of participants whilst archival review is considered to offer precise and detailed descriptions of conducts among stakeholders during the briefing process. The use of grounded theory methodology has also been considered crucial for identifying successful 'good practice' since the emphasis of the methodology is on the interplay between data and analysis in developing theories. Six cases have been identified and targeted in order to fulfil the set criteria. Further phases involve finalising the interview questions (to be tested with a pre-pilot interview) prior to performing the interviews and data analysis of the selected six case studies.

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Project Diagnostics – Assessing the Condition of Projects and Identifying Poor Health

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Abstract

In many cases, construction projects do not achieve the objectives that the project participants set for them. If participants could better understand how their project is performing overall, at various stages of its delivery, then the opportunities to achieve project success would almost certainly be greater.

This paper documents a method of assessing the status of a project, at a point in its design or construction phase, or after completion. The status is assessed in terms of up to seven (7) key success factors. Any evidence of less than adequate performance in these performance areas is scrutinised to seek out the root causes of why this situation is happening. Using these identified root causes of under performance, general suggestions can then be made as to how to return the project to good health.

A software package that assists in assessing the status of the project has been developed. The package is currently being calibrated before commercial release.

Keywords: Diagnostics, project status, project performance indicators, root causes

1. Project Diagnostics

1.1 The Gestation for Project Diagnostics

Many projects fail to meet predetermined objectives. This failure is a major issue adversely affecting the construction industry, and more generally, the community. From the need to better understand how to judge the prognosis for a particular project (in terms of its likely performance), the idea of developing a "diagnostic kit" arose.

Project Diagnostics is a research initiative of the Australian Cooperative Centre for Construction Innovation (CRC CI). Arup Pty Ltd (Arup) is a founding member of the CRC CI, and lead this research project. This project was undertaken by a team with industry, government, and academic expertise.

1.2 The Human Health Analogy

Humphreys, Mian, Sidwell, (1) identified parallels between construction project health and human physical health, and proposed that in many ways the “health” of a construction project is analogous to human health. Human health can broadly be thought of as the condition of the body. When physical health is poor, performance or quality of life can be compromised. Poor physical health often has associated symptoms that can be used to help pinpoint the cause of ill health quickly and accurately.

Once the cause has been identified, a remedy can be implemented to assist the return to good health. If symptoms are left unchecked, they can develop into critical situations. In many ways the ‘health’ of a construction project is analogous to human physical health:

- State of health influences performance
- Symptoms can be used as a starting point to quickly assess health
- Symptoms of poor health are not always present or obvious
- State of health can be assessed by measuring key areas and comparing these values to established norms
- Health changes temporarily
- Remedies can often be prescribed to return to good health
- Correct and timely diagnosis can avoid small problems becoming large.

Project health is synonymous with project performance. If a particular project aspect is not performing as expected it would be perceived as unhealthy, or failing. On the other hand, if it is fulfilling expectations, it would be perceived as healthy or successful. The requirement for rapid, accurate diagnosis leads to the concept of an initial broad health checking mechanism, which could guide further more detailed investigations. More detailed appraisals identify the more fundamental factors contributing to poor health.

1.3 Industry Need

Research during the latter part of 2002 indicated that a reasonably comprehensive tool to assist in the assessment of the state of the existing health of construction projects was not generally available. Ready access to such a tool would significantly enhance the opportunity for an under performing project to be appraised - and then corrected, in a focused and systematic way.

Project Diagnostics has developed such an assessment tool to aid understanding of the current condition of a project. The assessment identifies performance against industry benchmarks for the key success factors. Further analysis of any underperforming areas is carried out – enabling the probable root causes of poor performance to be captured. This diagnosis can then provide a prognosis for the success of the project, or otherwise. The diagnostic toolkit can then point the way to remedial actions that could be taken.

These activities are highly relevant to industry. If project participants are able to confidently compare how a project is currently performing against industry norms, then targeted action can be taken to improve performance, as necessary. The diagnostic toolkit can be then applied again at subsequent stages of the project, to continue to monitor the effectiveness of remedial action taken.

2. Methodology

2.1 Project Methodology

The Project Diagnostics methodology is shown in Figure 1. The following steps outline the methodology and should be read in conjunction with this figure.

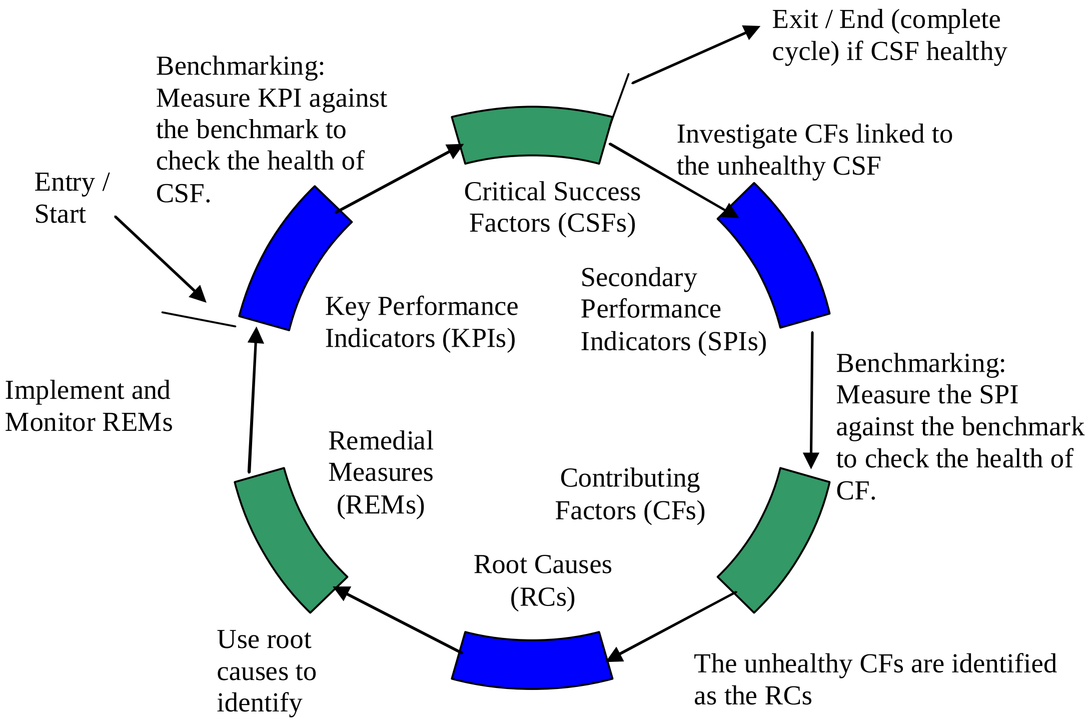

Figure 1: Project diagnostics methodology

2.2 Critical Success Factors (CSFs)

Research carried out in the last decade provides many sources of success and failure measures, totalling more than 120 different relevant measures. The measures have been split among different stages of a project. In order to make these extensive lists more manageable to work with, and to help analyse the interactions, they are represented by seven main measures of success. These are termed Critical Success Factors (CSFs).

The factors used for the assessment of current health of the construction project are:

- Cost
- Time
- Quality
- Relationships
- Safety
- Environment
- Stakeholder value

As is the case with human physical health, these measures are critical areas that can facilitate a broad evaluation of project health; they need to be investigated in order to ascertain project health.

2.3 Key Performance Indicators (KPIs)

The seven CSF themes represent critical areas of construction project health. In order to use these CSFs as indicators, they need to be properly assessed. This task was achieved by developing an associated series of Key Performance Indicators (KPIs) for each CSF.

The KPIs are used to measure the degree of acceptability of CSFs. Their value is compared to benchmarks, to check status. The aggregation of CSF status information provides an indication of the project health. This process involves collecting data from the project under scrutiny, calculating the KPIs, and comparing them with benchmarks.

The use of KPIs to assess the performance of the main CSF themes allows the model to be applicable to most (if not all) of the project stages and a majority of the procurement methods. To facilitate the KPIs application to assess the performance of the CSFs, they were calibrated using benchmarks from Australia (Coles 2003, (2)), UK (CBPP 2003 (3)) and USA (CII 2003 (4)). Calibration makes the model applicable to a project regardless of generally how the performance target was arrived at.

After careful scrutiny, a total of 33 KPIs were chosen. As an example, the KPIs for the "Cost" CSF follow:

Table 1: KPIs for Cost

CSF	Key Perf Indicators	Explanation of Indicator
Cost	CPI (Cost Performance Indicator)	CPI = BCWP / ACWP Where: BCWP = budgeted cost of work actually performed. ACWP = actual cost of work actually performed. CPI ≥ 0.85 indicates a healthy project. CPI < 0.85 indicates an unhealthy project. The benchmark is based on an average value of cost overrun of 15% from survey of 375 general building projects in the Giles Royal Commission (1992) into the productivity of building industry in NSW. This indicator provides a snapshot of the project cost at a particular point in time. The source for gathering ACWP would be the progress claims of the consultant/contractor showing the approved amount at that point of time. This will be compared with the BCWP at that time - can be sourced from the contractor/consultant cost plan. The budgeted cost should include approved variations.
	PJCI (Projected Cost Indicator)	PJCI = BAC / EAC Where: BAC = budgeted cost at completion. EAC = actual cost at completion (i.e. actual cost to date plus updated estimate of work remaining). PJCI ≥ 0.85 indicates a healthy project. PJCI< 0.85 indicates an unhealthy project. The rationale behind the above benchmark is the same as the CPI. This purpose of this indicator is to check the health of a project at completion based on the forecast from the particular point in time chosen for the snapshot for CPI. In order to check the health of a project as far as cost is concerned, the CPI & PJCI are considered together in terms of the following conditions: CPI < 0.85 & PJCI < 0.85 indicates an unhealthy project. CPI < 0.85 & PJCI ≥ 0.85 indicates an unhealthy project. CPI ≥ 0.85 & PJCI < 0.85 indicates a healthy project. CPI ≥ 0.85 & PJCI ≥ 0.85 indicates a healthy project. The CPI and PJCI are applicable to all stages of a project from planning to hand over.

It was necessary to validate the robustness of these KPIs by testing them on actual projects. Table 2 provides an explanation of how the indicator was used in testing.

Table 2: Example Cost Performance Indicator (CPI)

CSF	Indicator	Explanation of Indicator
Cost	CPI	Definition: CPI = BCWP / ACWP Where: BCWP = budgeted cost of work actually performed ACWP = actual cost of work actually performed Benchmark: CPI ≥ 0.85 indicates a healthy project CPI < 0.85 indicates an unhealthy project This provides a snapshot of cost performance on the day of health check.

For all relevant CSFs (up to seven), the results are then analysed and the overall health of the project is able to be assessed. If the results indicate a healthy project the cycle ends. Otherwise, the use of the toolkit proceeds to the next step.

2.4 Contributing Factors (CFs)

CSFs that were found to indicate project performance as being less than industry benchmark levels were used as the focus of a more detailed investigation. Factors leading to poor levels of performance against benchmarks were assessed; these factors are called the Contributing Factors (CFs). There is a direct relationship between CFs and the root causes of poor project performance.

A list of Contributing Factors associated with each CSF was developed in consultation with industry through pilot studies. Pilot interviews were conducted on projects identified by the industry partners from the research team. These interviews were conducted using a structured questionnaire. The respondents included clients, consultants, contractors and sub contractors. A total of 28 interviews were conducted. The questionnaire was designed to allow identification of CFs and to allow them to be ranked in terms of relative importance using a numeric scale. This list of CFs was augmented with CFs identified from a literature survey.

The CFs were further validated using a Delphi type approach using industry partners as specialists.

The overall ranking of the identified CFs for each unhealthy CSF from the pilot questionnaire was calculated, using a statistical frequency analysis.

Table 3 shows the rank and importance index for CFs for “Cost” as an example. The indexes are ranked in descending order.

Table 3: Rank and Index of Contributing Factors

CSF	Contributing Factors (CFs)	Index	Rank
Cost Overrun	Variations	14.7	1
	Inaccurate cost estimate	6.0	2
	Rework	3.3	3
	Lack of client decision making	2.7	4
	Competitive nature of market	2.3	5
	Poor quality of design and documentation	2.3	5
	Approvals	2.0	7
	Contractor / Sub-contractor work efficiency	2.0	7
	To manage project simultaneously a large component of work was done in another city branch office	2.0	7
	Poor workmanship	1.3	10
	Work sequencing with other trades	1.3	10
	Audit testing	1.0	12
	Change of management	1.0	12
	Emissions and under measures in documentation	1.0	12
	Lack of completeness of contract documents	1.0	12
	Limited resources	1.0	12
	Lack of architect higher management interest	0.7	17
	Productivity of workforce due to traveling involved due to remote location of project	0.7	17
	Relationship workshop	0.7	17
	High quality product required	0.3	20
	Higher management direct involvement	0.3	20
	Programming issues causing pressure on contractors	0.3	20

The importance index and rank for each CSF was found by calculating the average index for the rank 1 to 4 of contributing factors within each CSF. Table 4 shows the index and rank of the overall CSFs.

Table 4: Rank and Index of CSFs

CSFs	Index	Rank
Cost	6.68	1
Time	3.86	4
Quality of documentation - increase in RFI	3.20	8
Quality of construction - increase in rework	4.65	2
Safety	3.60	5
Relationships	4.15	3
Environment	3.40	7
Stakeholder value	3.43	6

As mainly successful projects were evaluated in pilot studies, the list of CFs was not considered comprehensive. Augmentation with CFs identified from a literature survey occurred. The CFs were further validated using a Delphi type approach using industry partners as specialists. Thes team members added CFs to the list obtained from pilot studies so as to achieve a comprehensive list. A second round of feedback on CFs was instituted with the research team. Finally they were discussed in a workshop attended by the same specialists to get a final list, based on the consensus of these specialists.

2.5 Secondary Performance Indicators (SPIs)

Like CSFs, the CFs needed to be assessed to pinpoint the areas most likely to be causing poor project health. This task was accomplished with a series of Secondary Performance Indicators (SPIs) for each CF. A number of key criteria, similar to those used for selecting KPIs, were also used for choosing SPIs. A sample of “Cost” SPIs follows:

Table 5: Example showing "Cost" SPIs

CSFs	Contributing Factors	Secondary Performance Indicators
Cost Overrun	Inaccurate estimating of cost	To measure the reliability of cost estimates, actual design or construction cost is needed and estimated design or construction cost; and using the formula: Performance Percentage Predictability = (Actual design or construction cost – Estimated design or construction cost) / Estimated design or construction cost and plotting this value on the Predictability - Cost curve indicates the performance level.
	Consultant / contractor lack of appropriate experience	Profile is an indicator - has consultant or contractor successfully completed a similar project in terms of size, locational restrictions, complexity etc. This indicator however needs benchmarking.
	Inflation	Magnitude has direct impact on cost estimates.
	Lack of trust in contractors and consultants by client	The policy adopted by the client may lead to teams' protecting their own position, resulting in loss of focus or reduced productivity.
	Adoption of inappropriate contract type	An inappropriate contract type (eg, Fixed, or Cost Plus, when scope is not well defined), can lead of cost overruns.

Potential SPIs associated with each CF were identified from the literature. As with the KPIs, these SPIs needed to be benchmarked. Benchmarks were identified through a literature review of research material from the UK, the USA and Australia. In addition, results from four projects of the project team members were used to validate the results. The results weer further reviewed in a workshop with industry research partners.

2.6 Root Cause Identification

Knowledge of the particular CFs failing to meet the target (benchmarked) values, provide the necessary insight to confidently identify root causes of poor performance. For example, if the relevant "Cost" CF was the use of an inappropriate contract type (as highlighted by the SPI), then the relevant root cause becomes almost self evident. In some cases, the CF and its root cause are quite similar. In other cases, such as the relevant "Cost" CF being inaccurate cost estimating, then the specific root cause needs further review; is the inaccurate cost estimating due to poor project scoping, or inadequate resources, or lack of skills, or some other basic cause? It is here that the experience of the project participants, and/or external professionals, comes into play.

Once the root causes were acknowledged, remedial measures associated with each of them were able to be identified: based on lessons learnt from the industry partners, through case studies, and from another literature search.

Correct and timely identification of contributing factors along with accurate assessment of SPIs, generally allowed an effective remedy to be prescribed, through insight into root causes of concern. The role of the subsequent remedies is to return the project to good health. Recognising the potential effect early and taking the proactive steps necessary to avoid unwanted consequences, can achieve this.

2.7 Remedial Activity

The practical nature of construction suggests that a suitable approach for development of a suite of remedies for a range of health problems would be based on the experiences of the project participants, but focused on the specific results of the CF/ SPI analyses.

A combination of the Project Diagnostics specifics, and a broad industry understanding is a powerful project improvement tool. In some cases, it may be appropriate to introduce independent industry professionals to assist the project team in this process.

One of the limitations of using lessons learnt is that remedies tend to be dependent on personal experience. This means that remedies for a given contributing factor or identified root cause, may vary from person to person – and potentially in conflicting ways. The approach for this model will be to develop a set of remedies that have proved historically to be workable and can achieve results.

However, it needs to be understood that each project is unique, with its own set of issues and most appropriate ways of restoring it to good health.

For this reason, remedies nominated in Project Diagnostics can be generic remedies only – and should only be seen as such, until and unless the particular project dynamics are clearly understood.

It is possible that single or multiple remedial measures will be associated with each of the contributing factors for the specific unhealthy CSF. The implementation of the measures may require the coordination of multiple project participants or stakeholders. Once implemented, time may be required time to restore the project to good health.

As necessary, the KPIs for relevant CSFs are able to be measured again later, to check if the cause of poor performance has been remedied. The cycle can iterate until the project health is considered to be satisfactory.

3. Software Development

3.1 Toolkit

The aim of Project Diagnostics was to develop a Toolkit that enables the user to:

- Investigate the health of a construction project
- Identify the root causes of poor health
- Give an indication of remedial measures which could be implemented to improve project performance and outcomes.

This toolkit has both the potential to be used as required when clients or other project participants feel that a project is not performing according to their expectations; and at regular intervals as a 'health check' during the delivery of the project.

The toolkit is designed to have integrated benefits that include identifying areas of poor project health, pointing to the probable root causes and suggesting possible remedial measures. It is envisaged that the use of the toolkit will be very cost effective for clients and stakeholders as compared with the costs associated with the adverse impacts of failing projects. These include cost and time overruns, inadequate build quality, poor project relationships, loss of reputation, public clamour and legal disputation.

The software development is well advanced. As at January 2005, commercial arrangements for the finalisation of the software toolkit are being finalised.

3.2 Validation

Further validation of the KPIs, CFs and SPIs, and linkages to case studies are required, before the package is ready for commercial release. To date, four case studies during the later stages of development of the toolkit have been used to validate the model and refine the parameters used. Ten pilot projects were used earlier in the initial development of the approach used in the software.

Comprehensive validation of the software package is intended to be complete by early 2006. The package will then be available for commercial use. Expectations are high for the benefits that Project Diagnostics will bring to the entire industry.

4. Conclusions

Project Diagnostics aims to bring the benefits of industry knowledge and experience, built up over many years, to project participants. By assessing the state of critical success factors for construction projects, at various stages of progress, it is possible to gain a confident view as to the likely prognosis for success of the project.

The software toolkit automates this assessment. The toolkit facilitates the identification of areas of project under performance. Use of the toolkit will assist in setting appropriate remedial measures, to facilitate the restoration of the project to good health.

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Documenting the Real Causes for Delay in Highway Construction Projects

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Abstract

For the past three years, Florida Department of Transportation (FDOT) construction contracts have run approximately 23,000 days over original contract time each year. These extended days comprised 28%, 23%, and 25% of the original contract days, respectively. During the same period, the cost of the projects averaged $124 million per year over the original contract amount. Even though the increase did not result entirely from the extended days, it is reasonable to assume that the project cost increase is related to the time extensions in some way.

The data for this paper were obtained from the FDOT database. FDOT posts “Construction Cost and Time” Quarterly Reports on their website, with available data including project location, duration, cost, contract type, and delay days.

FDOT categorizes delay days as either weather days, time extensions, or supplemental agreement days, depending on the circumstances. The time extension (TE) heading and supplemental agreement days (SA) heading both are broken down into 12 sub-headings of circumstances, which can cause delay. These 12 sub-categories are the same for both SA and TE. The twelve categories of extended days (TE and SA) and weather days are analyzed in this paper as causes for delay in highway construction projects.

The goal of this paper is to analyze the factors that influence contract duration for highway construction. Also of interest is the relationship between delay and cost increases, so a regression model was developed showing that relationship. Using the results of this analysis, a comparison between regions of the state representing urban and rural areas, and a comparison between contract types (unit cost, lump sum, and others) were made so that parameters could be set for estimating more reasonable schedules for future projects depending on project regions and contract types. Finally the most prevalent causes for delay in highway construction projects are identified.

Keywords: Delay, weather days, time extension, supplemental agreement, project cost changes, regression model, lump sum.

1. Introduction

There is a growing need for rehabilitation and reconstruction to sustain the U.S. highway system. However, while desperately needed, the construction causes many problems, such as inconvenience and delays for road users and economic loss for communities. Shorter construction durations usually produce better results in terms of safety for the public and construction workers because the public is exposed to the work zone for shorter periods of time. Other advantages of shorter construction durations are lower road user costs due to minimizing traffic delay and lower overhead costs for both the contractor and public owner (agency).

In reality, however, it is very difficult for a construction project to be constructed both "on time," and "within budget." Delay is one of the most common problems in the construction industry. FDOT had 22,835 delay days in fiscal year 2001/2002 (28.4% of the original contract duration), and, although they decreased to 22,634 days (22.6% of the original contract) in fiscal year 2002/2003, the delay days increased in 2003/2004 to 23,919 days (25.2%).

Over the last three years, FDOT has averaged spending $124 million per year more than initially planned for construction projects. FDOT paid $1,240 million to the contractors in fiscal year 2001/2002, for projects originally contracted at $1,104 million. The amount paid also increased from an original $1,399 million to $1,522 million in fiscal year 2002/2003 and from an original $1,387 million to $1,501 million in fiscal year 2003/2004. By analyzing the factors affecting construction duration for transportation construction projects, reliable parameters can be set up concerning the relationship between delay days and project cost changes, with variability depending on region, contract type, and district characteristics.

The subject of construction delays has been analyzed previously by many researchers, but most of the studies have been conducted using survey results. Very little information was found which described research using delay analysis that included delay days from actual transportation projects.

2. Literature Search

The problem with project delays is not a new one. Contractors are obligated to complete construction projects within a time period specified under the contract, so time is one of the most important aspects of a construction project. However, unexpected delays and problems routinely occur, that affect time and cost. Therefore, many studies related to the influence of delays on construction projects and various statistical analyses have been conducted.

From more than 4,000 projects constructed over twenty-seven years (1959-1986), research showed that surprisingly few projects were actually completed within their budget and on schedule [1]. As far as the impact of delay on project performance, U.S. and international research reveal that many nuclear power plant projects in the U.S. experienced an increase in project cost and duration [2]. Arditi et al. reported that the percentage of projects successfully completed on schedule in Turkey ranged from 8% to 15% [3]. Some extreme examples were reported such as a hospital construction project that was completed after a delay of 6 years, amounting to 233% of the original construction duration.

Many previous studies have discussed causes for delays. In studying large building projects in Saudi Arabia, Assaf et al. outlined 56 causes and grouped them into 9 major categories [4]. As a means of delay factor identification, a survey was used and results of that survey indicated that the delay factors categorized as “financial” were ranked the highest (most delay), whereas those delay factors categorized as “environmental” was ranked the lowest by all three groups of respondents - contractors, A/E, and owners. Baldwin and Manthei stated that the major causes of delays in building projects in the United States were weather, labor supply, and subcontractors [5]. These results were also obtained from a survey given to engineers, architects, and contractors.

Majid and McCaffer classified the main causes of non-excusable delays and then identified the factors contributing to those causes using the Ishikawa, or fish bone, diagram [6]. To determine the ranking of the factors, they used previously published reports. For the first three major factors contributing to causes of non-excusable delay, late delivery, damaged materials, and poor planning are identified.

Some studies have discussed the issues relating to delay analysis. Bubshait and Cunningham compared three delay measurement processes, which are as-planned schedule delay analysis, as-built schedule delay analysis, and modified as-built schedule delay analysis. They then showed that one procedure might be more reliable than others in certain circumstances [7]. Computer-aided construction delay analysis for preparing claims was studied by Alkass et al. [8]. They presented an integrated computer-based system (CDCA) as an improved method of analyzing delays and preparing claims. Shi et al. presented a construction delay computation method at the activity level [9].

Many previous studies have discussed subjects relating to delays. When the studies dealt with causes or reasons, conclusions were mostly based on survey results from the respondents and data that were based on the literature review. As noted earlier, no major study has been done to explain causes for delays in transportation construction projects using actual delay data from construction projects.

3. Data Gathering

Data for this paper were taken from Construction Cost and Time Quarterly Reports of the Florida Department of Transportation (FDOT) for the duration between fiscal year 2001/2002 and fiscal year 2003/2004; however, the report for fiscal year 2001/2002 was posted as an entire year instead of each quarter on the Internet. Therefore, when the data were analyzed to see if there was a trend of factors affecting delay by time, the entire 2001/2002 report was used instead of a quarterly report.

In the Quarterly Reports, data is shown for projects that had been completed through that particular quarter within that particular fiscal year, cumulatively. Table 1 shows the number of completed projects for each district by fiscal year. A total of 1,205 projects completed between fiscal year 2001/2002 and 2003/2004 were used for the analysis. Obtainable data from these 1,205 projects included the district in which each project was performed, original contract days, delay days, original contract amount, final contract amount, and contract type.

Table 1: Number of Projects Completed

District	Number of projects completed			
	2001/2002	**2002/2003**	**2003/2004**	**Total**
1	52	46	49	147
2	66	90	68	224
3	54	114	79	247
4	39	46	54	139
5	50	59	52	161
6	24	37	40	101
7	28	60	40	128
8	10	23	25	58
Sum	323	475	407	1205

The term "delay days" means all days over and beyond the original contract days; it does not necessarily mean that projects are behind schedule. The delay days can be divided into three categories according to circumstances surrounding the delay: weather days, TE, and SA days. The TE and SA days are also divided into 12 sub-categories according to the reason for the added time. These 12 sub-categories are the same for SA and TE. For this research, weather days and 12 reasons for extended days were considered as factors causing delays (total of 13 factors). In the Construction Cost and Time Quarterly Reports, these 13 delay factors are expressed in the form of number of delay days based on original contract days.

Interviews were conducted as part of the data verification process after analyzing the data from the quarterly reports. Weather archives were also collected in order to verify whether the weather days granted to the contractors coincided with inclement weather as documented by the weather service.

3.1 Identification of Delay Factors

SA Days are those days that were granted as part of a Supplemental Agreement. A Supplemental Agreement is a legal document that amends a FDOT contract in some way. TE days are simply days granted the contractors by FDOT according to FDOT procedures under circumstances that do not require a SA. Weather Days are days that are granted by letter because weather prevented the contractor from working on critical work items on a specific day. Weather Days do not include any damage to the project caused by weather.

Since days granted for weather are not actually added to the contract, the total TE and SA days are the total number of days added to the contract; therefore, the difference between TE and SA days is just in the mechanism by which extended days are granted.

The twelve reasons (sub-categories) for delays granted by either SA or TE are changed conditions, plans modifications, specification modification, value engineering, partnering, CEI action/inaction, minor changes, defective materials, weather-related damage, claims, utility delays, and invalid reason codes.

"CEI" is the term used for a consulting firm that performs construction engineering and inspection (CEI) services. CEI action/inaction means that contract change was brought about by some action of the CEI. It could have been a decision to change something or a lack of decision where the contractor requested some action.

Weather-related Damage means days granted as either a TE or by SA because some damage was caused by weather where the contractor had to redo some of the work.

4. Data Analysis

First, factors that influence contract duration were identified as described. The number of delay days that contractors were granted was then obtained and sorted according to which of the 13 factors caused each delay for each quarter from fiscal year 2001/2002 to fiscal year 2003/2004, and the following analyses were done.

1. Factor Distribution
2. Comparison of delays by geographic region, district, demographics, and contract types.
3. Cost vs. Delay Analysis.
4. Regression Analysis of the relationship between delay days and project cost changes.

4.1 Factor Distribution

Delay distribution by fiscal year (representing time) and district (representing location) reveals whether or not a specific type of grant for delay days, such as Weather Days, plays a significant role in the total number of delay days granted.

Figure 1 shows the delay distribution by fiscal year according to grant type. In fiscal year 2001/2002, 63% of all delay days were either SA days or TE, and 37% were Weather Days, whereas in fiscal year 2002/2003, 52% of all delay days were SA or TE and 48% were Weather Days. In fiscal year 2003/2004, delay distribution is also 48% Weather Days and 52% either TE or SA Days. One possible explanation is that according to the weather service there were 12% more rain days in fiscal year 2002/2003 than in 2001/2002 (281 days versus 251 days).

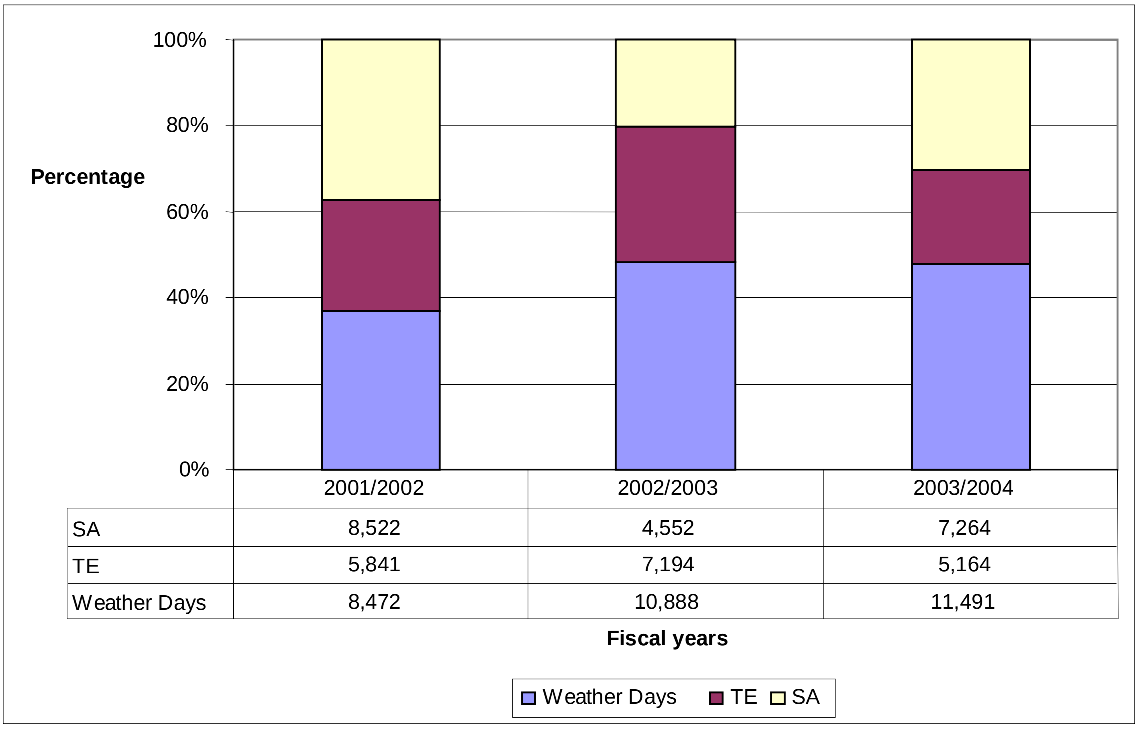
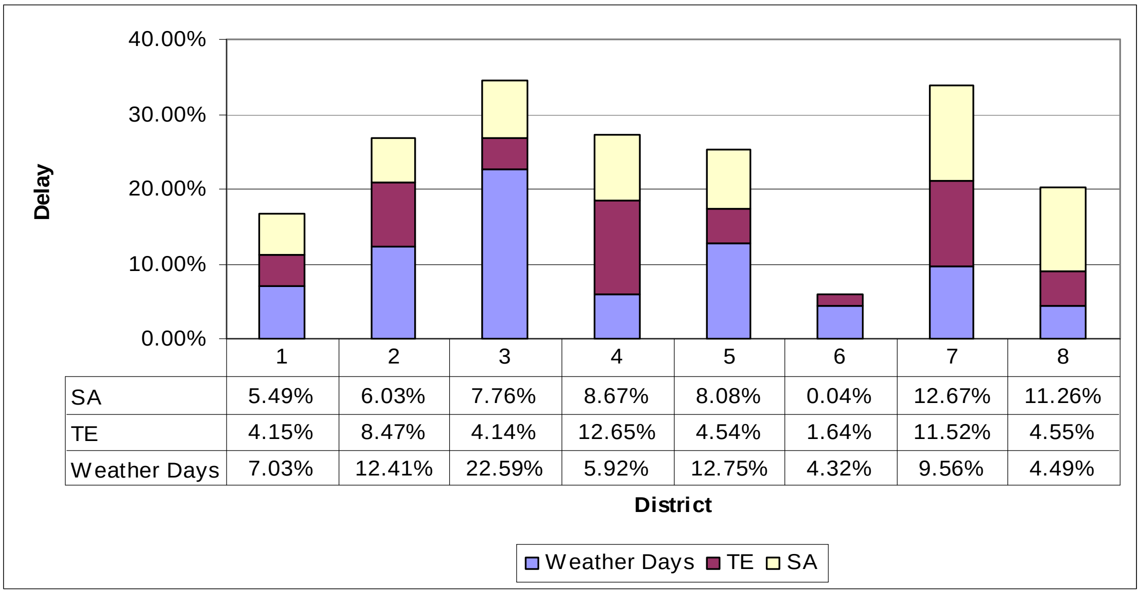


Figure 1: Statewide Delay Distribution by Each Fiscal Year

The weather archives at the National Climate Data Center under the National Oceanic and Atmospheric Administration (NOAA) classified rain days as either >0.1" rain days, >0.5" rain days, or >1.0" rain days. The research team concluded that >0.5" rain days would generally seriously affect construction projects. To determine the number of rain days in each district, major cities in each district were randomly selected, and the number of rain days in each city was sought. The average rain days among these cities, then, represented the number of rain days in each district, so 281 rain days in fiscal year 2002/2003 means that the sum of each district's average number of rain days from July 2002 to June 2003 is 281days.

According to the delay distribution results during the three years, the proportion of Weather Days and TE/SA Days looks quite consistent.

Delay distribution by district for the three years is presented in Figure 2. District 3 has significantly more Weather Days than any other district in Florida. Weather Days will be discussed later in detail.



District	1	2	3	4	5	6	7	8
SA	5.49%	6.03%	7.76%	8.67%	8.08%	0.04%	12.67%	11.26%
TE	4.15%	8.47%	4.14%	12.65%	4.54%	1.64%	11.52%	4.55%
Weather Days	7.03%	12.41%	22.59%	5.92%	12.75%	4.32%	9.56%	4.49%

Figure 2: Delay Distribution by Districts (2001/2002 – 2003/2004 Total)

Weather days, plans modifications, and changed conditions comprised 44%, 22%, and 20% of the total delay days, respectively. So, these 3 factors comprised approximately 86% of the total delay days while the other 10 factors accounted for only 14% of the delay days. Among the 10 less significant factors, CEI action/inaction and utility delays were responsible for 6% and 4% of the total delay days, respectively. Delay days due to factors such as specification modification, V.E., partnering, defective materials, claims, and invalid reason were very small, with each factor accounting for less than 1% of the total delay days.

4.2 Comparisons

4.2.1 By Region

As noted earlier, District 3 had significantly more weather delay days than any other district. This district is in northwest Florida, and encompasses the "big bend" and "panhandle" areas. The district has a long coastline, so there is a possibility that District 3 had more rain days than other districts. To verify this, weather archives from NOAA were checked. Table 2 shows that District 3 had more rain than the average in other districts in terms of precipitation and more rain days (>0.5"). The difference in precipitation, however, was just 10 inches over 3 years, and the difference in rain days was just 11 days over 3 years. This difference does not explain the wide gap in weather delays.

Conjecture is that perhaps District 3 has a more lenient policy regarding the granting of weather days than other districts, but this cannot be verified by any form of documentation.

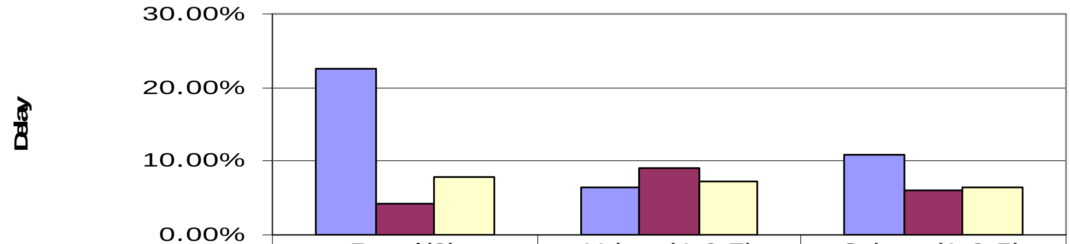
Table 2: Weather Comparison (2001/2002 – 2003/2004)

	District 3	Others (Avg.)
Precipitation	164.44	153.69
Rain Days (>0.1")	199	204
Rain Days (>0.5")	105	94

4.2.2 District Characteristics

Because there were more weather days in District 3 than expected, the research team suspected that granting extended days might be affected by district characteristics. Excepting District 8, which is a turnpike district with no real geographic identity, the research team classified Florida's districts into three categories. Districts 4, 6, and 7 were categorized as "urban" areas. District 3 was categorized as a rural area, and District 1, District 2, and District 5 were categorized as areas with both characteristics, or "mixed."

Figure 3 indicates that not only did District 3 (Rural) have more weather days than the other two groups (Urban and Mixed) but delay composition rates also increased gradually from the rural group to the urban group. It is inferred that the more crowded districts are less likely to grant delay days for weather. In addition, even though the difference is not significant, the sum of TE and SA in each group gradually increased from the rural group to the urban group, which is consistent with the general belief that urban projects are more complicated because of their confined working conditions and therefore more susceptible to the 12 areas of potential delays under the TE and SA headings.



	Rural(3)	Urban(4,6,7)	Others(1,2,5)
Weather Days	22.59%	6.50%	10.91%
TE	4.14%	9.16%	6.06%
SA	7.76%	7.33%	6.46%

Figure:. Delay by District Characteristics (2001/2002 – 2003/2004 Total)

4.2.3 By Contract Type

The total number of delay days in District 2 was relatively small, and it was learned that a significant number of days were given back to FDOT through SAs. Further analysis was done to determine why District 2 had a negative number under the heading "SA days."

Among the number of SA days going back to FDOT, which meant time savings, a disproportionate number came from lump sum contracts. District 2 had more lump sum contracts than any other district in Florida in terms of number of contracts and total contracted amount. Most FDOT lump sum contracts in District 2 were completed on schedule. To reveal why lump sum contracts had such good results in terms of the schedule, interviews were held with FDOT personnel in District 2.

It was found that many of the lump sum contracts in District 2 were landscaping projects. Unlike other districts, District 2 has a policy that landscaping work be pulled out of roadway construction projects and given separate contracts.

Conventionally, the contractors are given two growing seasons in a contract that includes landscaping to make sure that plants are well established since production rates for plants can't be determined at the time of planting. Separating the landscaping from the rest of the contract allowed District 2 to eliminate this extra time by having contractors put a warranty on the landscaping plants. Warranty bonds now guarantee that contractors will water the plants after contract time expires, so that time can be given back to FDOT. Burn-in periods for traffic signal contracts are now being handled the same way [10] in this district.

In order to have the best probability for successful lump sum contracts, plans must be better than those of unit price contracts [10]. The fact that there are fewer conflicts concerning quantities begins with the assumption that plans and specifications are clear enough to avoid quantity arguments. If plans and specifications are not good enough, then more conflicts between contractors and the CEI will arise and lead to an adversarial relationship between them, which hinders the success of any project.

As for the process of selecting the contract type, in District 2, resident engineers chose whether they want a lump sum contract or a unit price contract on a specific project. Once it is decided, resident engineers meet with design engineers to formulate a plan that conforms to that particular contract type.

4.3 Relationship between Time and Cost

Intuitively, highway projects that have no, or lower, time extensions have lower overall costs than those with higher time extensions. Figure 4 shows this to be the case. Projects that have higher time extensions are shown to cost, on average, more than projects that have no, or lower, time extensions. In Figure 4, plotted dots represent the number of delay days and the difference between initial cost and final cost for the quarter's projects.

In order to ensure that there was a statistical relationship between extended project duration and project cost, and to further analyze the details of that relationship, statistical analysis was performed, using multiple linear regression.

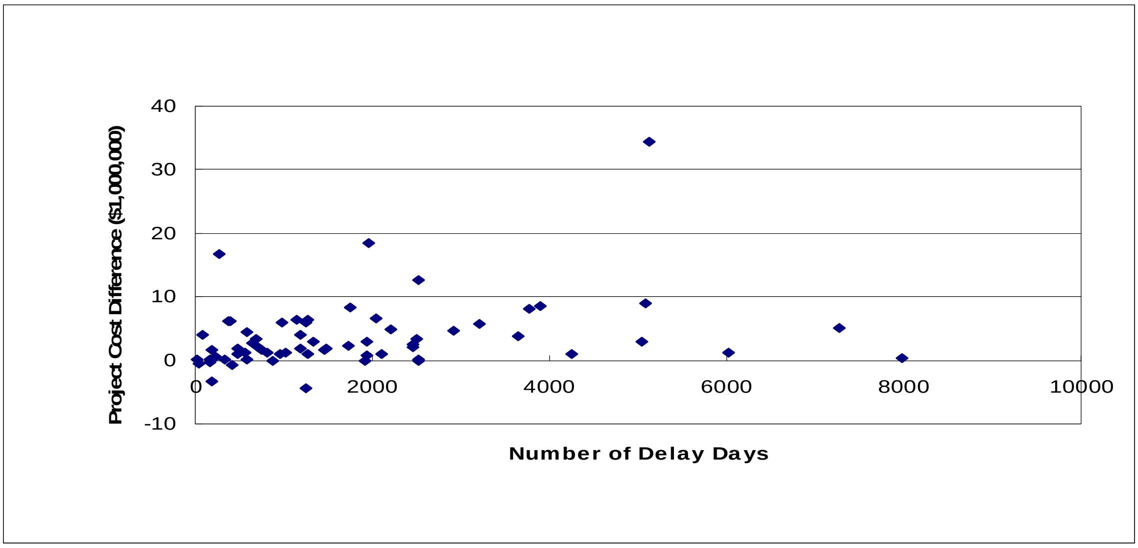


Figure 4: Delay Days vs. Project Cost Changes by Quarter/District

4.3.1 Regression Model

Regression analyses were performed to determine the statistical relationship between a response and the variables. In this analysis, the response was the project cost difference, and the variables were delay factors such as weather days and these factors found under the SA and TE headings such as changed conditions, plans modifications, and specification modification.

Several assumptions are required for the regression model. The regression model is expressed in the form of EQUATION (1).

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_p x_{ip} + \varepsilon_i, \quad i = 1,2,\ldots,n \qquad (1)$$

And, the assumptions of the model are:

- y_i is regarded as the response that corresponds to the levels of the explanatory variables $x1, x2, \ldots, x_p$ at the ith observation.
- $\beta_0, \beta_1, \ldots, \beta_p$ are assumed to be the coefficients in the linear relationship. If there is a single factor ($p = 1$) for the equation, β_0 will be the intercept, and β_1 will be the slope of the straight line defined.
- $\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n$ are assumed to be errors which make a scatter pattern around the linear relationship at each of the n observations. These errors are mutually independent, are normally distributed, and have a zero mean and variance, σ^2, under the assumption of the regression model.

The method of least squares was used for both its mathematical simplicity and its ability to provide explicit expressions for estimates of the coefficients in the regression model. The research team assumed that since each variable is a distinct and separate factor in the FDOT system, no interactions between the variables would be considered.

Sixty-four data sets were used, derived from eight quarterly reports, with each report containing eight districts in Florida. From the data sets, all 13 delay factors were chosen for the regression analysis at the first stage; however, a factor (partnering) was removed from the first regression equation because there was no time alteration to any contract over this time period attributed to partnering.

The results for the regression analysis at the first stage revealed that at the 90% confidence level, only two of the 13 factors (plans modifications and minor changes) were statistically significant.

Tables 3 and 4 show the regression and the ANOVA statistics for the final equation. From Table 3, it is interesting to note that when all of the insignificant factors from the first stage were eliminated, only the delay days due to "plans modifications" continued to have a significant relationship with the project cost changes. Even though there were many delays due to weather days, the relationship between weather days and project cost changes was not statistically significant. The weather days might affect the contractor's cost, but they don't seem to impact the owner's cost.

In Table 4, the P-value indicates that the regression as a whole is very significant for a significance level of less than 1%. The coefficient of determination, R^2, indicates that over 60% of the variation in the variables is explained by the regression model, shown in EQUATION (2).

Project Cost Difference ($100k) = 4.23 + 0.204 Plans Modification Delay Days (2)

Table 3: Regression on Delays

Variables	Coefficients	Standard Error Coefficients	t-ratio	P-value
Constant	4.230	5.323	0.79	0.43
Plans Modifications	0.204	0.020	10.30	0.00

Table 4: ANOVA Statistics for Regression on Delays

Source	Degree of Freedom	Sum of Squares	Mean Square	P
Regression	1	123,522	123,522	0.00
Residual Error	62	72,199	1,165	
Total	63	195,721		
R^2	63.1%			
R^2 (adj.)	62.5%			

The adjusted coefficient of determination R2 (adj.) is a rescaling of R2 by degrees of freedom so that it involves a ratio of mean squares rather than sums of squares. This removes the impact of degrees of freedom. Unlike R2, R2 (adj.) need not always increase as variables are added to the model. The value of R2 (adj.) tends to stabilize around some upper limit as variables are added [11].

Figure 5 indicates how the regression equation fits the data. When the values derived from the regression equation are put on the y-axis and the values of actual project cost changes are placed on x-axis, the scattered dots show a linear trend. In this drawing, the ideal estimates will lie on the 1:1 line, which shows that the derived value is exactly equal to the observed value of actual project cost change.

Even though the regression equation proved significant for project cost changes, the assumptions of the regression model should be checked to see if they are satisfied. Homogeneous variances and normal distribution of experimental errors are among the most important assumptions. Residual plots are carried out to provide visual evaluations of the analysis of the constant variance assumptions, which assumes each data point is equally reliable [12].

The residuals e_i measure the discrepancy between the data y_i and the estimated or fitted model $\hat{y}_i$. If the constant variance assumption is satisfied, then residuals will follow a distribution with a zero mean and variance, σ^2. In addition, the residuals should be plotted randomly, having 95% of the residual points within a 2σ horizontal band around zero.

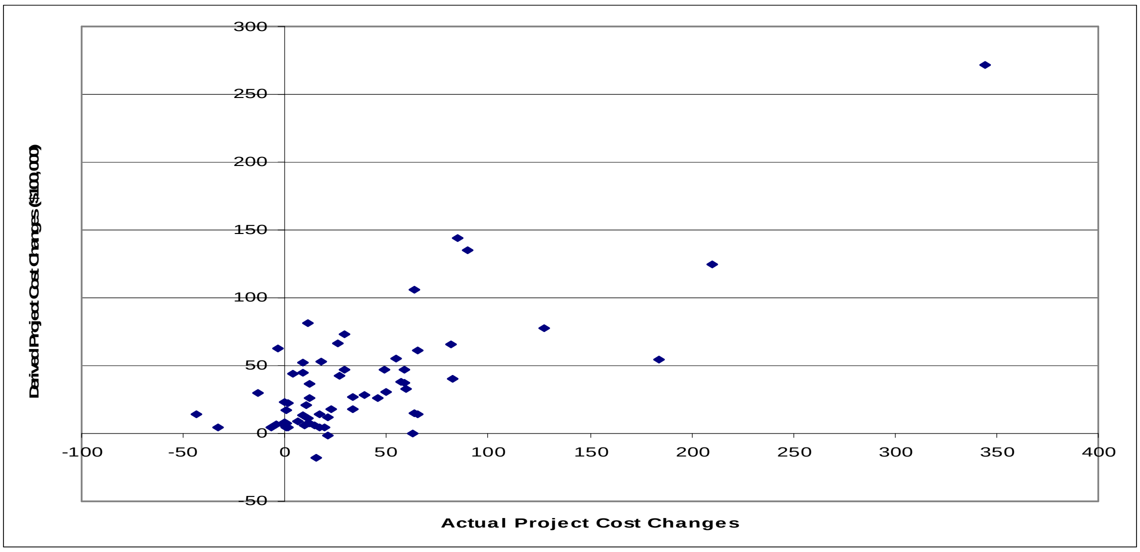


Figure 5: Actual Project Cost Change against Fitted Project Cost Change for Linear Regression Model

In Figure 6, when the residuals from the regression model are plotted against fitted values of the regression equation, any evidence for a nonrandom pattern can be detected. Further, it can be determined from Table 4 that most of the residuals should exist between the ranges of $\pm 2\sqrt{1,165}$, or ±68.26 since the mean square of the residual error in the ANOVA is an estimator for σ^2, which is 1,165. From Figure 6, it is proved that most of the residuals are between the anticipated ranges; showing approximately two points are located outside this range, or 3% of the total observations. Therefore, it can be concluded that the constant variance assumption is satisfied. One of the purposes of deriving a regression equation in this research was to assist in predicting project cost changes in highway construction projects using actual delay days. With the resulting $R2$ value of 63.1%, it can be said that actual project cost changes can be estimated using the actual delay days under each category.

5. Conclusion

This paper presents an analysis of factors influencing contract duration for highway construction and multiple regression analysis of the causes of delay in transportation projects. Delay distribution was quite consistent, and the composition rates among the grant type of delay days (Weather, TE, and SA) did not change much unless there were noticeable changes in rain days.

The granted weather days were compared to actual weather reports at the National Climate Data Center. Even though both documented precipitation and the number of weather days granted in District 3 were greater than the other districts, the difference in weather days granted was significantly greater than the difference in documented precipitation.

Weather days were the number one reason for delays on highway construction project. Plans modifications and changed conditions were also major reasons for delays.

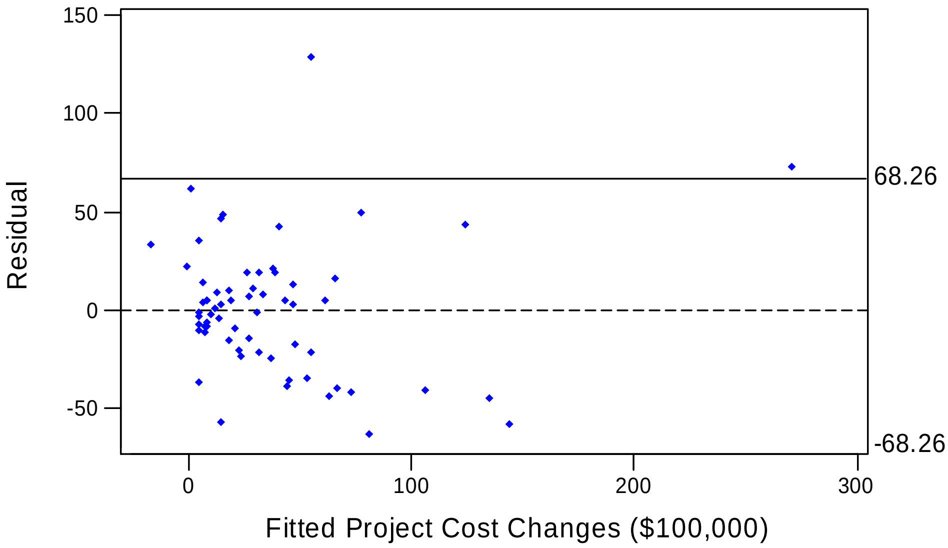


Figure 6: Residual Plot for Linear Regression Model on Project Cost Changes

The composition of the total delay days varied from district to district. The more rural the district, the more weather days were granted on average; and the more urban the district, the more TE and SA days were granted. TE and SA days are made up of changed conditions, plans modifications, specification modification, value engineering, partnering, CEI action/inaction, minor changes, defective materials, weather-related damage, claims, utility delays, and invalid reason codes.

Contract type also had an influence on project duration. In this research, the lump sum contract was noted to have played a positive role in projects having shorter project durations. One reason for lump sum contracts having shorter durations was that landscaping projects were contracted using lump sum contracts with warranty bonds separately from roadway construction projects. With the warranty bond and motivated contractors, the lump sum contract was, then, successful, and FDOT received many days back from contractors through SAs.

Regression analysis was performed, and multiple linear regression determined the statistical relationship between project cost differences and project delay. In this analysis, the regression model for project cost changes has provided a regression equation that satisfies over 60% of the variance. Among the 13 delay factors analyzed as part of the first stage, only delay days due to plans modification had a significant relationship with the project cost changes.

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Benchmarking Project Management in the United Kingdom: Developing the Measuring Instrument

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Abstract

The paper is an output from the research being undertaken by the Task Group in Project Management, which is part the activities of CIB W65. The objective of the research is to benchmark the activities of practising project managers against the Project Management Institute – Body of Knowledge. The methodological approach is a survey of practitioners. This paper reports on the development and piloting of the survey questionnaire that was designed with input from the Task Group in Project Management. The resulting questionnaire is presented and discussed in a UK context. The results show that the questionnaire will form a suitable basis on which to survey current practice. It will allow the assessment of the extent to which practitioners in the UK have the skills to undertake the various project management activities, how much of their time they commit to them, and how valuable they consider their outputs.

Keywords: Body of knowledge, project management, skills, value

1. Introduction

This paper sets out the findings of the development stage of the benchmarking study in project management. It is designed to inform a debate in the CIB W65 Task Group in Project Management on how to proceed with data collection on role of the project manager in the United Kingdom (UK) as the first study in a collection of national studies. The paper sets out a review of project management standards and justifies the choice of the Project Management Institute – Body of Knowledge (PMBOK) as the basic structure for data collection in the benchmarking process. The rationale for the development of a data collection tool is explained and the findings of a pilot of a questionnaire are discussed and reported.

2. Literature Review

The problems and difficulties of the UK construction industry in terms of it delivering satisfactory service levels to its clients have been well documented by various government reports over the years (Simon[1], Emmerson [2], Latham [3] and Egan [4]). In summary, such problems may be classified as not managing project budgets, timescales and/or quality standards. In general, research suggests that the overall track record of British organisations in managing projects leave much to be desired. BS6079 [5] acknowledged such poor levels of performance prevail when it commented "the delivery of projects on time within pre-determined cost and to the requisite standard within set constraints of established safety and quality criteria are less frequent than they should be".

In essence, these concerns are related to the product of the construction management process. It can be argued that to only focus practice based research on the resolution of such symptoms of construction project management problems is misplaced, as attention also needs to be given to a wider agenda related to the processes (or causes) which produce such symptoms of professional service dissatisfaction. Support for this view can be drawn from the work reported by Hibberd and Djebarni [6]. This study with UK construction industry clients and their consultants ranked for importance the factors that they considered being issues in the delivery of construction projects. This survey revealed that although product or goal related factors such as time (3%), cost (6%) and quality / design faults (16%) were issues that were considered to be problematic there were others. The other factors rated by the respondents to that survey that were more related to the processes used to provide construction project management services such as, change requirements (25%), teamwork (25%), communications (18%), and project team responsibility / roles (5%). The general issues related to the management processes that UK based construction industry consultants use to deliver their services address matters such as what services, how are they structured, when are they delivered and to what quality levels are they provided. For the purposes of this work those concerns have been put into context by addressing matters related to construction project management functions and standards, activities and timescales and quality service level benchmarking. Each are now considered below.

2.1 UK National Project Management Standards and Functions

In the UK, there are two main methodologies, namely, Prince 2 and BS6079 that can be used as the basis of a strategic project plan document. The Prince 2 system can claim to be the *de facto* standard for the UK government and local authority usage. The Prince 2 and the PMBOK cover many of the same topics and both represent best practice. Waterman [7] identified the main sections of the Prince2 system as being, project start-up or initiation, planning, directing or executing, controlling and closeout.

The establishment and revision of the BS6079 [5] standard also aimed to help management address the issues highlighted above. The standard has been developed from a perceived need of central UK government and as a document it is divided into five sections, namely, (i) general matters, (ii) corporate aspects of project management, (iii) project and company organisational structures, (iv) project management processes, (v) project life cycles. Coe [8] has already undertaken small-scale quantitative research studies into the usefulness of BS6079 in practice. In the study it was found that only 40% of respondents were even aware of the existence of BS6079 in its original form. Similarly, concluded that BS 6079 does not yet appear to be taken seriously by the UK construction industry.

2.2 International Project Management Standards

Formal planning and management programmes have developed greatly since the 1950s when the US defence industry introduced the PERT network. From such early developments there has been a continual drive to develop project management standards and certification on a world-wide basis. Many countries and many sectors of industry either have or are attempting to produce their own individual standards so as to formalise their project management techniques. The internet based PMforum hosts a world wide listing of regional, national and international professional project management organisations. It lists on its web pages a total of 35 separate national project management associations from across Europe, Asia, and the Americas - see www.pmforum.org. This proliferation of standards and approaches is presently being addressed by the Global Standards working party and its brief is to establish a global standard that can be used to establish professional competence. Some of the most widely known and used international project management standards are now set out for consideration,

The Project Management Institute (PMI) set out in their Body of Knowledge (PMBOK) what they claim is the necessary guidance on the processes and knowledge required by practitioners involved in managing single projects. Its main sections cover the management of risk, management of people, and the management of time. This standard is seen as being the industry standard that can be applied on a global basis to promote the project management profession. However, as indicated above other standards available include the following,

The Engineering Advancement Association of Japan (ENAA) has produced its own Project Management Body of Knowledge. The Japanese have looked to see how project management can help innovation and improve business value. The standard was initiated by the Japanese Project management Forum (JPMF). The project management book of knowledge concentrates on the management of projects rather than the management of differing systems that make up individual projects. The four main sections of the ENAA BoK are objectives, strategy, value, management and finance. It is interesting to note that this BoK places emphasis on the management of finances and it also covers the management of programmes which is an area that the PMBOK has been criticised for overlooking. This Japanese standard has been heavily influenced by the government and it has been tailored to its needs.

In Germany, there are the DIN standards and the PM-Kanon standards that are most used in relation to project management standards.   The DIN standards that are applicable are DIN 69900, 69903 and 69905. These standards relate specifically to the definition of terms and processes used in project management. The standards also give local and national compliance requirements that are similar to the UK British Standards. These standards are essentially national in application and are not seen as having any influence or relevance outside Germany.

The Cost/Schedule Performance Management Schedule was developed in Canada. This standard was developed specifically for major crown and other government projects. In the guidance note it is made clear that this standard is not intended for use on projects which are related to the production of commercial services. Canada is further developing a separate project performance management standard. This is being produced by a joint industry / government working group and its aim is to produce a more straight forward document / standard. The working group have taken on board the development of other standards such as those operating in Australia and the US Department of Defence. In time this will give this revised standard a wider than just national relevance to Canada

There are two main standards in Australia which relate to project management. One standard, AS4360, refers to managing risk in Australian public service. This standard is the one used by the Australian National Audit office to audit projects and programmes undertaken on behalf of the Australian government. The second is the Australian National Competency Standard for Project Management. This is a national standard sponsored by Australian Institute of Project Management. This standard was developed with the aim of promoting the profession and being used as the basis for the certification of professional standards. The PM BoK was used as the initial baseline for the standard and as a result the standard is good in the assessment of an individual's competence but it is limited in its use to the Australian context. Indeed, Turner et al [9] commented that in keeping with other standards "this standard does not prescribe how project management competence should be developed".

The Association of Project Managers Body of Knowledge was developed in 1986 primarily to address all aspects of education and training of project managers in the UK. It is not seen as a standard to be used for the implementation of project management services. Rather it is seen as a mechanism to structure certificated training. The APM and other nationally based standards are based on the PMI body of knowledge that is becoming accepted as the global standard. The standards and guides indicated above detail the functions or the 'what' that constitutes the potential range of services that construction project management needs to address. The next issue to consider in order to begin to establish common approaches to construction project management are the process by which such services are delivered.

2.3 Project Management Activities

During the construction project lifecycle it is self evident that project management activity should be centred on ensuring that the project achieves its recognised success factors. Previous work by Morris and Hough [10], Nicholas [11], Keeling [12] have between them all developed comprehensive lists of issues that construction project managers need to address in order to ensure their management activities are best directed towards the achievement of project success. In summary the principal features advanced in the literature revolve around the conventional issues of project management activity being focused on the management of time, cost and quality during the construction or implementation stage of the project delivery lifecycle. However, Winch [13] notes that such a focus on conventional project success criteria provides a narrow view of what project lifecycle activities actually need to be addressed. Winch [13] suggests that such a view is limited in that it takes as given solutions to the problems during briefing and design and it ignores the differing interests of all project stakeholders. Winch suggests that project management services that focus on such narrow conventional criteria is an approach that is product or goal orientated rather than one that takes cognisance of the processes by which such goals can be achieved.

Burke [14] suggests that project management activities that focus on the processes by which the project life cycle is fully implemented need to address issues that can be grouped under the following headings, namely, the concept and initiation phase, the design and development phase, the implementation and construction phase, and the commissioning and hand-over stage. Given this wider perspective it follows that the time project managers allocate to the differing phases of project delivery should be distributed across the project lifecycle and not exclusively focused on the project's construction or implementation phase.

2.4 Benchmarking

Benchmarking is the term applied to the method of comparing best practices amongst peers or competitor organisations to identify, and adopt best practices that can help a particular organisation to improve the level of its services to its clients. Keeling [12] identifies the concept of benchmarking to be an established mechanism used by project management organisations to ensure that they learn from the experience of themselves and similar business organisations. However, work by Somerville and Stocks [15] indicated that the prevailing 'blame culture' together with the fragmented nature of the UK construction industry may well combine to frustrate the same characteristic of competitive benchmarking to become as established in the UK construction industry.

3. The Project Management Process

3.1 The PMI Body of Knowledge

The Project Management Institute established its first Project Management Body of Knowledge in 1976 on the premise that there were many management practices that were common to all projects and that codification of this "Body of Knowledge" would be helpful not just to practising project management staff but to teachers and certifiers of project management professionalism. It was not until 1981, however, that PMI's Ethics, Standards and Accreditation Committee submitted its recommendations for a BoK to the PMI Board of Directors. These were published in the August 1983 issue of the Project Management Quarterly, and this subsequently formed the basis for PMI's initial accreditation and certification programmes. A revised document was published in the August 1986 issue of the Project Management Journal and approved by the PMI board in August 1987 as the "Project Management Body of Knowledge". Further work by PMI's

Standards Committee resulted in a revised document titled "A Guide to the Project Management Body of Knowledge". This was done to emphasise that even though the document defines the PMBOK as all those topics, subject areas, and intellectual processes which are involved in the application of sound management principles to projects – a claim which this paper will question – it will never be able to contain the entire PMBOK which is out there in the universe of project management. A further revised and updated version was published in 1996. Trademarking of the term PMBOK was recently sought by PMI. Currently, the structure of the PMI's PMBOK™ document consists of "generally accepted project management practices" represented by 37 component processes. It also includes a description of what the PMI defines as the "project management framework": definitions of key terms, a description of pertinent general management skills, and an introduction to the concept of a project management process model (Morris, [16])

3.2 The Construction Extension to the PMI Body of Knowledge

In 2000, PMI issued its Construction Extension to the PMBOK. In the introduction to the extension, the PMI states that the extension "supplements, modifies, reinforces and expands the profession's *de facto* global standard in an easy-to-use format for practitioners in the construction industry" (PMI, [17]). The extension introduces four additional activity areas – project safety management, project environmental management, project financial management, and project claims management. The activity areas of the PMBOK and the Construction Extension are shown in fig. 1.

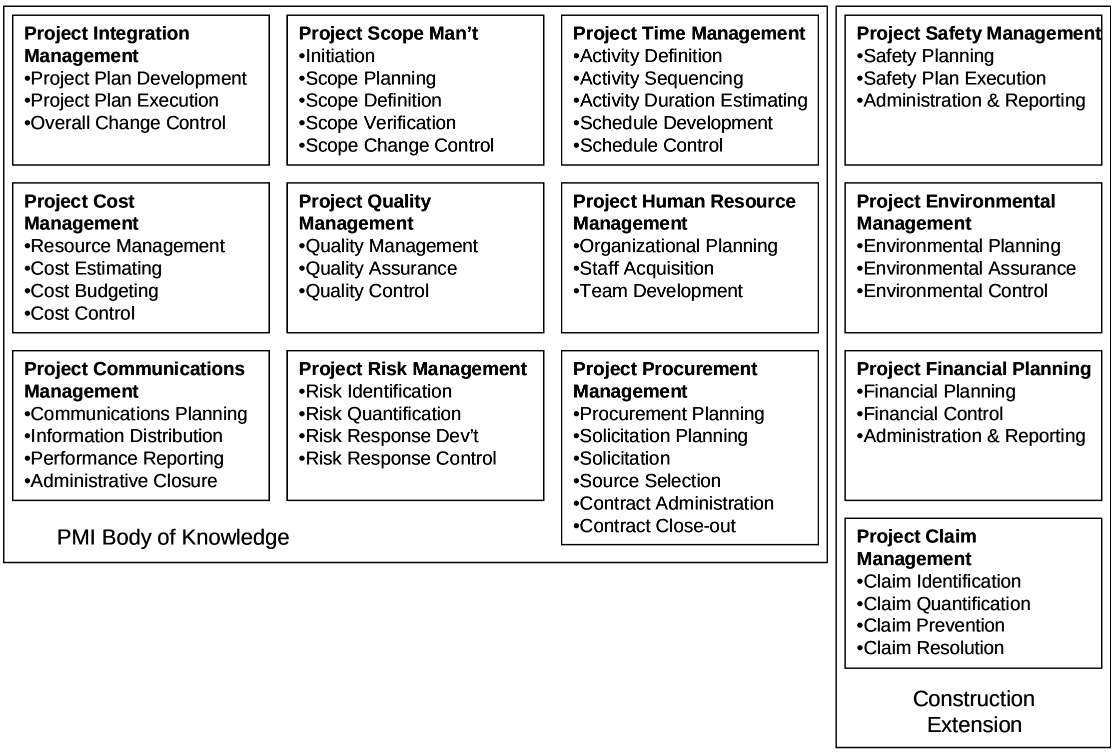

Figure 1 The PMBOK activity areas and the construction extension

4. The Benchmarking Process

4.1 The Task Group in Project Management

The Task Group in Project Management was set up under the CIB W65 Organisation and Management of Construction in 2002. The objectives for the task group include an international benchmarking exercise on the role of project management. The argument for this was articulated in the proposal:

> The globalisation of construction, particularly for large infrastructure projects, creates situations where companies from across the world come together in a unique partnership to solve a particular problem, often working under the direction of a single, project management consultant. Those postgraduate programmes for project management that recruit in a global market are recruiting well and from counties all over the world. There is little or no evidence to suggest that the elevation of the importance and significance of the project manager is confined to the United Kingdom, it is a global phenomenon.

This benchmarking study has two components:

1. A quantitative study designed to examine the role of project managers in construction projects in different countries. This part will attempt to gather data as widely as possible.
2. A qualitative investigation into the factors affecting the differences between countries.

This paper presents the findings of the development of a measuring instrument for part 1 of the study.

4.2 Developing the Measurement Instrument

The measuring instrument has been developed following workshops held alongside CIB symposia in Singapore and Toronto. The PMBOK provides the structure for the benchmarking process. It gives a total of 13 activity areas that are sub-divided into 43 sub-activities (see fig 1).

The starting point is what is meant by role? A dictionary definition would be: 'the actions and activities assigned to or required or expected of a person or group'. This is an important issue in this context and goes to the heart of the investigation. Role descriptors are usually ascribed to individuals or groups of individuals and any examination of 'role' must, therefore, focus on the individual within the process. For this study, the focus is on the role of the project manager in the management of construction projects.

It must be recognised that the term project manager is generic and that the function of the project manager may be undertaken by a separate consultant with the title of project manager, or by any other actor engaged in the construction process, or indeed a combination of these. If it is the role of project manager that is to be benchmarked, rather than the named persons duties, it is important that data is collected on who is performing the duties of project manager?

The next issue is about the investment made by the project manager in discharging their obligations. Here data can be collected on the relative use of manager's effort, in the form of time, across the activities in the PMBOK. This follows on from the study reported by Fortune and Lees [18]. Data also needs to be collected on the perception of value added by each of the activities. This will allow for the alignment between effort and value to be assessed.

Finally, it is important to capture data about the respondents, to establish whether there are trends that affect their execution of the role. Here it is proposed to examine the level of experience, appropriateness of formal education and training and discipline background of the respondent.

The framework for the measuring instrument is summarised in figure 2.

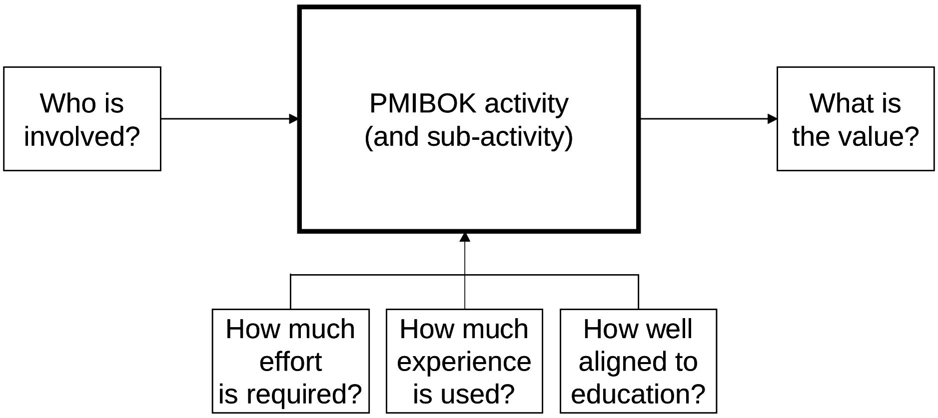

Figure 2 – Rationale for the development of the measuring instrument

4.3 Validating the Questionnaire

For the purposes of this development process a paper questionnaire was prepared in accordance with the principles established in fig 2. The questionnaire in its first form runs to several pages and there is insufficient space here to reproduce the whole questionnaire. However, fig 3 shows the typical arrangement of the questionnaire and also shows an example of how it was completed.

In the pilot study, the questionnaire was given to five practitioners to complete along with a supplementary set of questions that asked questions about their experiences of filling it in. These questions covered ease of understanding, time taken to complete and appropriateness of questions.

The respondents found the questionnaire relatively easy to understand, although there was some confusion over how to respond to the question on the proportion of their time spent on different activities. The main problem here was a lack of certainty over what constituted 100% of their effort. Was it the amount of time spent as a consultant or was it only the amount of time spent as a project manager? Confusion on this matter led to a lack of clarity in the data collected.

The time taken to complete the questionnaire was considered to be too long and likely to have a detrimental affect on the response rate. This matter will need to be discussed by the Task Group before a final decision on how to proceed can be taken. The options would appear to be either to make the sample of respondents a smaller, solicited sample that only includes those who have agreed to respond, or to improve the efficiency of the data collection by making the questionnaire a web-based data entry form. The latter has certain attractions as it would remove the confines of A4 paper sheets and allow a greater level of instruction on how to complete the form.

The general view of the respondents was that they felt the questions were appropriate, but they did not feel qualified to comment on this as they were not fully aware of the purpose of the research.

7. Project Cost Management	What proportion of your time as project manager is given to this activity?	How do you rate the [see below] (where 0 = low and 5 = high) – circle as appropriate: The value-added by your engagement with this process	Your value of your experience to this process	The value of your education to this process	Which of the following ***actors*** has **primary responsibility** for the process? You as project manager	Client	Architect	Engineer	Constructors	Specialist constructors	Others please specify	*Quantity Surveyor*
7.1 Resource Planning - determining what resources (people, equipment, materials) and what quantities of each should be used to perform project activities.	5%	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	☐	☐	☐	☑	☐	☐	☐	☐
7.2 Cost Estimating - developing an approximation (estimate) of the costs of the resources needed to complete the project activities.	5%	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	☐	☐	☐	☐	☐	☐	☐	☑
7.3 Cost Budgeting – allocating the overall cost estimate to individual work activities.	2%	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	☐	☐	☐	☐	☐	☐	☐	☑
7.4 Cost Control – controlling changes to the project budget.	10%	0 1 2 3 4 5	0 1 2 3 4 5	0 1 2 3 4 5	☑	☐	☐	☐	☐	☐	☐	☐

Figure 3 – Example a completed part of the questionnaire

Overall, the pilot demonstrated that the questionnaire design is a reasonably robust and reliable basis on which to develop the measuring instrument. Further work is required in refining the tool before it used to collect data in the UK as the first part of the benchmarking process. A workshop is to be held in Helsinki to move the development to the next stage.

5. Conclusions

The main finding of this part of the study is that the basis on which the measuring instrument is designed is reasonable and robust. However, further refinement is required before the data collection can be undertaken in a full study. This refinement needs to be informed by the debate in the next workshop meeting of the Task Group, which is to take place in Helsinki in June 2005.

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Process Oriented Integrated Management System - Development and Implementation

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Abstract

The management system of Skanska Talonrakennus Oy is an integrated system, which addresses the following aspects: quality, environment, occupational health and industrial safety. The system describes the best practices applied to planning, implementation and improvement of activities as well as the responsibilities of different individuals. The indicators of the management system are intended to support continuous improvement of operations.

Upgrading of the management system was started because the previous functional management system had some significant inherent shortcomings. The old system was not sufficiently customer-oriented, did not support cooperation between the various units and functions, and did not help conceptualize the whole. In addition, the system, maintained in hard copy folders was onerous to update, and reporting of indicators required much work and was not illustrative.

The goals set for the new process-based system were not so much standard-oriented as business-oriented and their purpose was to support the strategic goals of the company. The method chosen was tightly scheduled teamwork led by the process owners and supervised through the different phases by an external expert, Mr. Kai Laamanen. Definition of customer-oriented goals proved to be a good way to help understand customers' expectations and challenge the existing management practices that were the result of the functional system.

The digital management system has proved to be a good concept at the construction sites and offices of Skanska Talonrakennus. The extensive material is logically organized in the system, and documents of the reference material are easy to find. At the same time, the digital system has significantly accelerated the development of the entire management system of Skanska Talonrakennus. Reporting and analyzing of indicators has reached an entirely new level thanks to the software. The reports are illustrative, they are produced on real time and decision-making concerning needed actions on their basis has become more dynamic.

Implementation of the process concept throughout the organization is not yet completed. In 2005, resources will be dedicated especially to training, reference material of the system, and reporting on safety findings. Judged on the basis of the positive first experiences, the reform of the management system has been a significant step in the right direction. In the future, the new system will be a good support for achieving the strategic goals of Skanska Talonrakennus.

Keywords: Management system, process, implementation, improvement

1. Need for Development of the Management System

1.1 Role of Skanska Talonrakennus Oy's Management System

The management system of Skanska Talonrakennus is an integrated system which addresses the following angles: quality, environment, occupational health and industrial safety. The system is certified in respect of all of the above-mentioned areas.

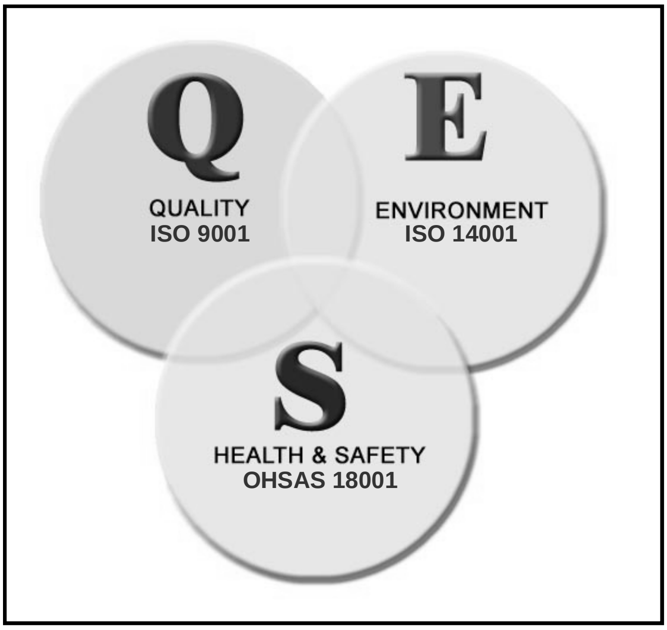

Figure 1. The three components of the integrated management system: quality, environment and health & safety.

The management system plays a significant role in the daily work of all Skanska employees both at the construction sites and offices of the company. The system describes the best practices of the company for planning, implementation and improvement of activities as well as the responsibilities of different individuals. Every Skanska employee has the duty to follow the management system in his/her individual duties.

The indicators of the management system support continuous improvement of operations. Financial, qualitative, environmental and safety performance capacities are measured by several different indicators. Further actions and development projects are determined on the basis of the measuring results.

This article describes the project for reforming the management system, its premises, goals and implementation as well as the characteristics of the new system.

1.2 Problems Associated with the Functional System

Until 2002, the structure of the management system was functional. The management practices were described as entities consisting of different functions. For example planning supervision, bidding calculation and production were such functions. The function procedures were described by means of written procedure descriptions and internal functional process charts. The system also included a large amount of reference materials, such as model plans, forms checklists and model documents. The system was quite viable and was generally considered to have no other defects except its heaviness and the extensive volume of its material.

However, this functional structure had several shortcomings. Firstly, the system contained no description of the customers' activities. The matters described in the system were based on Skanska's internal needs, not on the customer's expectations and requirements. It was impossible to understand the customer's role by means of the system, and customers' expectations were not very significant in the system improvement process.

The functional way of describing the system did not support cooperation between the different corporate units and functions; instead cooperation depended on the active commitment and skills of individuals. In addition, transmission of information between different functions was given relatively little attention.

A third significant question was the conceptualization of the whole. In the functional system, each function had its set goals which could, however, be conflicting with the goals of other functions, the goals of the entire company and those of customers. Employees also had difficulties in conceptualizing the operation of the entire company and their own role in it.

1.3 Problems with the Paper-based System

Previously the functional system was recorded in hard copy folders. About 1,500 Skanska employees in Finland had their individual system folders. Implementation of improvements was difficult, because even the smallest change required duplication of at least 1,500 hard copies of the document and their distribution to different parts of Finland. For this reason, the system was updated only once or twice a year. Small instant improvements were not carried out.

In the manual system, compilation and reporting of the measuring results was tedious work. It required an estimated work contribution of 20 people every six months to collect data on the qualitative, environmental and safety indicators. In addition to hard work, the reporting thus also lagged behind the real situation, and the clarity of the reports was only passable, and it was not easy to identify problems and improvement targets.

2. Goals Set for the Reform of the Management System

2.1 Goals of the New Management System

The management of Skanska Talonrakennus considered the success of the project for reform of the management system as critically important due to the dominant role of the system. The goals defined for the new system were not so much standards-oriented as supportive of the strategic goals of the company. Another goal was to create a system that would serve as the framework for planning of all activities and development in Skanska. Process approach provides a good basis for 3D modeling and standardization of construction projects where Skanska has allocated significant resources in recent years.

An important aspect is that the true objective of the system reform was to achieve the benefits offered by the process approach. The reform turned out to be a large project where the operations of the company were described in an entirely new way. The change of processes required by the new standards could have been achieved by a much easier updating of the system by just calling the existing functions processes and the persons responsible for the functions process owners. But such a flimsy reform would not have generated any new benefits, and the activities and their evaluation would have continued largely unchanged.

The goals defined for the new management system were:

- Our customers are more satisfied.
- We manage the risks.
- Our implementation costs are reduced and our productivity improves.
- The quality of our operations and products improves.
- We deliver the projects on schedule with zero defects.
- Control of our environmental and safety matters improves.
- Our cooperation network together with us does its best to achieve the above-mentioned goals.

2.2 Goals of the Reform Project

A challenging target schedule was set for the reform of the management system. The work was started in April 2002 and the system was to be ready for use and for training of personnel in April 2003. External audits in accordance with changed standards ISO 9001:2000 and OHSAS 18001 were performed in June 2003. In this connection, the environmental standard (ISO 14001 remained unchanged. In addition, the working method of the reform project was to utilize the best skills and knowledge of personnel and support widespread commitment to the goals.

3. Project for Reform of the Management System Step by Step

3.1 Theory Applied

Skanska Talonrakennus had no previous experience from a process modeling and development work of the type of this project. There was, however, ongoing cooperation with Kai Laamanen, a leading Finnish process expert, for instance connected with self-assessments. He was a natural choice as our cooperation partner for this development project, because he was already familiar with Skanska's operations and his process expertise was widely recognized.

It was agreed with Laamanen that he would train Skanska personnel in process management, and would then serve as instructor in the project, supervising and commenting on the different work phases. The three project phases presented in this chapter follow the model for building of process system, presented in Laamanen's book "Manage your business as a network of processes". The terminology used is from Laamanen's book " Terms and concepts in business process management". [1], [2]

The basic theory of process approach is that there is a certain chain of processes used by the organization to generate value to the customer. This generation of value must be managed in the organization and the operative result of the organization is generated in this process. [1]

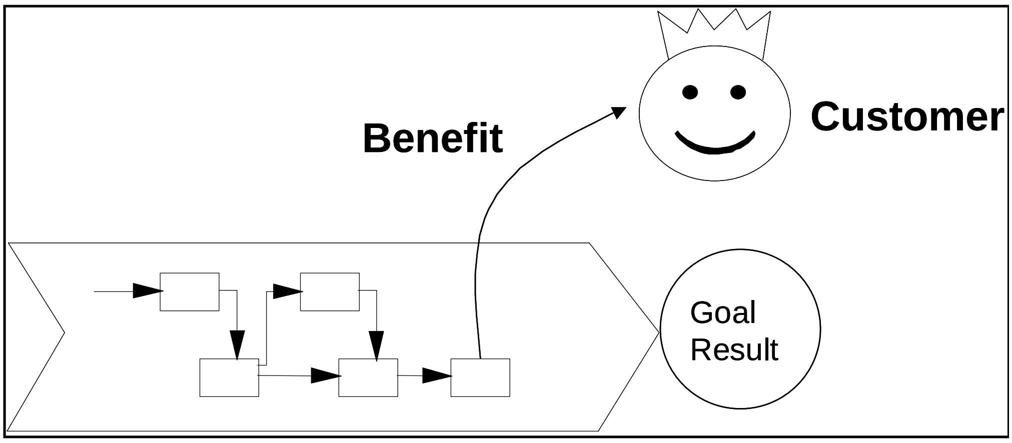

Figure 2. Value generation and target-setting.

3.2 Work Method

In March 2002, a schedule with intermediate goals was created for the project for reform of the management system. The working method came to be such that all persons who participated in the reform project held a joint meeting of a day or half a day at the beginning of all the project phases described in the following chapters. The status of the work and the guidelines for the following phase were reviewed under Laamanen's guidance. Small teams established for each process continued working between the meetings. Each small team had a chairman, and the chairmen were later also appointed as process owners.

APRIL – MAY 2002
Process training to process owners and quality managers
JUNE – AUGUST 2002
Definition of customer's operations
SEPTEMBER 2002
Definition of the inputs, phases and products of all processes
OCTOBER – NOVEMBER 2002
Appointment of process owners. Writing of process descriptions
DECEMBER 2002 – MARCH 2003
Modeling of processes; linking of reference material by means of QPR ProcessGuide
APRIL 2003
Training of Skanska personnel
MAY 2003
First meetings of process development teams
JUNE 2003
External audits

Process owners, key persons and quality managers did the work (50 persons)

Figure 3 .Schedule of the project for reform of the management system.

3.3 Training of Key Persons

Knowledge and skills were seen as key success factors for the project. Training events were organized in April and May for about 35 Skanska employees. Basics of process approach and measuring of indicators were the training themes. The persons who participated in the training were mostly members of senior management and quality managers. These persons and 15 other Skanska experts subsequently participated in every phase of the reform project described in this document.

3.4 Definition of Customer's Operations

Definition of the customer's operations consisted the first phase in the creation of the new process-based management system. Families who buy houses, clients who want to build residential projects, companies investing in commercial and office premises (e.g. insurance companies) and users of commercial premises are customers of Skanska Talonrakennus.

The customer's operations were initially described on a summary level. Six main phases of the customer's operations which illustrate the operations of all the above-mentioned customers in relation to Skanska were described on this level,. The customer's operations were defined during June – August.

3.5 Identification of Processes

The core processes of Skanska Talonrakennus were identified in August 2002 on the basis of the customer's main processes. The role of these core processes is to supply the best possible service to the main phases of the customer's operations efficiently and profitably. The number of these identified processes was five.

Also the most important support processes were identified. Support processes are internal processes of the company that create the preconditions for the function and results of the core processes. The number of these identified support processes was eight.

The above-mentioned core and support processes are Skanska Talonrakennus Oy's key processes and they play a major role in achieving the performance targets of the company. This is why their adequate description and continuous improvement are important. Several support functions whose development in this connection was not considered critically important were excluded from the management system. The customer's operations and Skanska's key processes are presented in the process chart on the highest level of the management system.

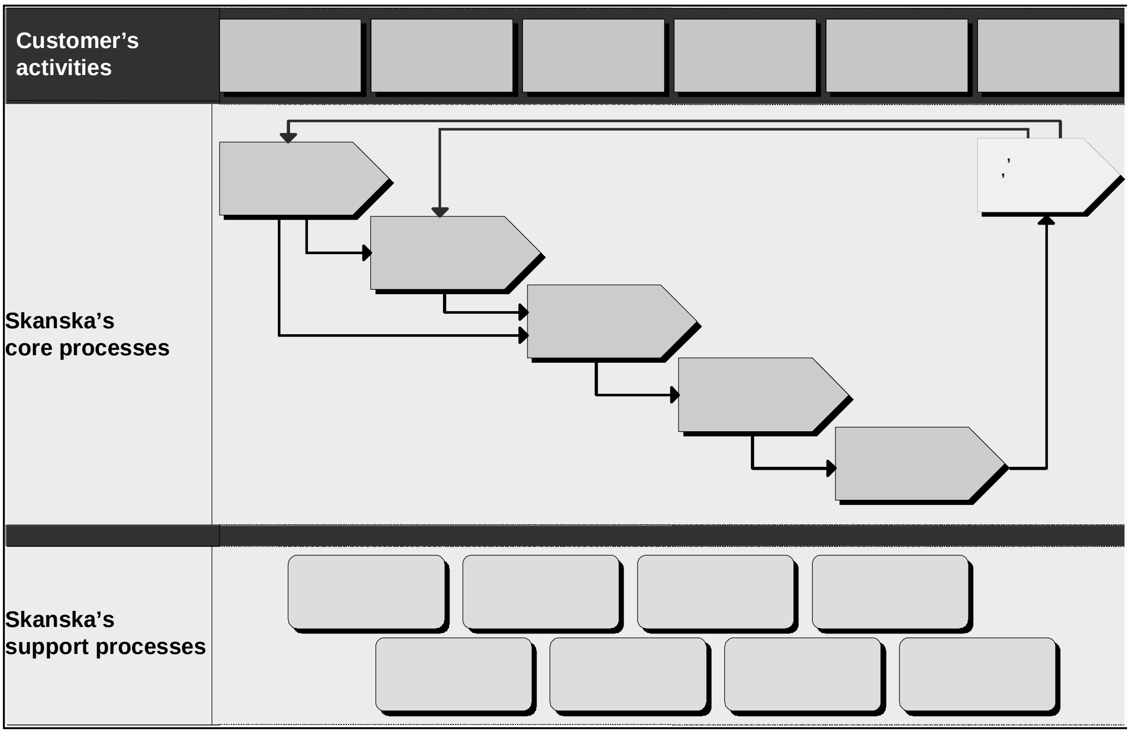

Figure 4. Structure of Skanska Talonrakennus Oy's process chart.

3.6 Setting of Process Boundaries

The boundaries of all processes in the management system were defined in September 2002. This was done by defining the inputs, phases and products of each process and also what happens before and after each process. These boundaries helped get a picture of the process contents and especially of the integrity of the core process, ensuring that the products of the previous core process are inputs of the next one. This also ensures that the processes really go from customer to customer and begin with planning (anticipation) and end in evaluation (learning).

3.7 Appointment of Process Owners and Writing of Process Descriptions

At the beginning of October 2002, an owner was appointed for each process. The owners are typically members of senior management who are in a prominent and influential position. Their first duty was to form a development team for the process, representing extensively all the units and the best know-how within Skanska. The first task of the process development team was to write a verbal four-page description of the process. To facilitate this writing work, all members of the team were given standard headings and questions that should be answered. The process description includes among other things:

- Purpose of the process
- Critical success factors of the process
- Main process phases
- Process indicators
- Process improvement
- Central roles functioning in the process.

In other words, the process chart is part of the process description. The process description is necessary to understand the operations and the critical factors that impact them (e.g. importance of cooperation). This supports operations, management and improvement. The purpose of management is to help people understand their own roles and the critical factors in the functioning of the organization.

3.8 Creation of Process Charts and Linking of Reference Material

The period from December 2002 to March 2002 was used to prepare the process charts by means of the QPR software, and to link the reference material to these charts. Certain basic rules were applied to the preparation work, e.g.

- The maximum permitted number of boxes (= functions in a chart) is 20, in other words only matters critical for success are described
- The charts start from the customer and end to the customer
- The customer is on the top line
- The following lines include Skanska’s different roles, or task definitions
- The functional text must describe activities and be a sentence

- The charts describe who performs the tasks in reality, not only who is ultimately responsible for the matters. [4]

Drawing of the process charts led to extremely fruitful discussions in the process development teams. The straight-forward way of presentation forced the teams to put the processes of the company and the relating functions in an accurate order of priority. Sometimes the description progressed easily in a spirit of good cooperation, while at times there were lengthy discussions about the priorities of doing things and who should do them.

The reference material: instructions used in daily operations, forms, checklists, etc., were linked to the process charts. As a result, more detailed relating material can be accessed from each function box of the process to make implementation easier.

3.9 Training of Personnel and Introduction of the System

The training events organized for all staff in April 2003 were quite straightforward. The first hour of the events was used to review the ideas and goals of process management as well as the changes in the structure of the management system. During the second hour, the participants practiced the use of the management system software in a computer class. After one hour of practice and final test everybody could use at least the basic functions of the system, such as roaming between process charts and retrieval of data. In connection with the training events, the hard copy system folders were collected from personnel and the fully digital system was taken into use.

The quick introduction of the system was supported by the following aspects:

- The basics of the process approach are accurate and straight-forward and aim at efficiency, and are therefore meaningful for business
- The goal of the system was simplicity of content and user interface
- Only the basics were taught during the first training round to ensure that the big organization did not need to absorb too many things at once
- General improvement of computer skills to ensure that users did not find the digital system as frightening or difficult to conceptualize
- Strong role of the management and other key persons in implementation and marketing; in other words, there was no uncertainty about the importance of the matter.

3.10 First Meetings of the Process Development Teams

The first meetings of the process development teams were held in May 2003. At that time, people had one month of experience in the use of the system. After this, the development teams have convened regularly and decided on improvements on the system.

3.11 External Audits

SFS performed the external certification audit of the system in June 2003. In the audit, the new process model was found to be good, and the auditor made very few comments about it.

3.12 Improvement of Measuring Indicators; Further Development

Continuous improvement of the system has continued energetically even after its introduction. Improvement of the measuring indicators has been a special priority during 2003 – 2004. The content of the indicators has been reviewed and improved from the angle of process efficiency and strategies. Reporting and analyzing have taken a significant leap forward following the introduction of the measuring software.

4. Digital Management System

4.1 Requirements

The environment where the management system and its computer applications are used is challenging. Skanska Talonrakennus has about 200 construction sites in different parts of Finland. The sites may be in tightly inhabited population centers and in city centers, or in very sparsely populated areas. The system must function right from the beginning of the site with the available telecommunication connections which can be of a varying quality.

The system must be easy to use, modern and attractive. Both process modeling and the use of the material of the management system must be simple and logical.

Since the management system is continuously used in 200 projects and many support processes, the system must be reliable. We cannot afford interruptions in its use.

4.2 Piloting

On the basis of a brief comparison, the process and score card software supplied by QPR Software Oy seemed to be the most attractive alternative. As the matter concerned the development of a system covering the entire personnel, we wanted to make sure before the investment decision that the characteristics of the software that would be purchased should meet the requirements of usability and information technology.

To ensure suitability, the software was pilot tested before acquisition. We agreed with the software vendor about a pilot project in which all parties participated to supervise fulfillment of their specific requirements. The software was tested at some sites and Skanska offices in different parts of Finland. Skanska's data administration unit tested its suitability for the existing IT environment, and the management evaluated the benefits of the software in its meeting.

Piloting confirmed the suitability of QPR, and there have been no surprises in this respect during the two years of use.

4.3 Use of the Digital Management System; Benefits in Production

The digital management system has proved to be a good concept at the construction sites and offices of Skanska Talonrakennus. The extensive material is logically organized in the system, and the documents of the reference material are easy to find. A basic user needs to know only a few functions, which makes the use of the system more meaningful and efficient. Another benefit for the users is that now the definitely most up-to-date and currently valid system material can be found in one single place on Skanska Intranet.

The digital system has significantly accelerated the development of Skanska Talonrakennus Oy's management system. Small improvements to the reference material are a virtually continuous process, because it takes very little effort to immediately make the updates available to the entire organization.

A new level has been reached in the handling of the measuring indicators thanks to the software. Reporting on quality, environmental and safety indicators used to be tedious, outdated and non-conceptual. Today, after the indicator system has been created, data can be entered in the system on real time, and the most recent information about the performance ability of the company is continuously available by means of the selected indicators.

The way of presenting the measured results is also illustrative and invites discussion. Green light indicates a performance that meets or exceeds targets, yellow is passable, and red is poor. Analysis of process indicators and decisions concerning further steps have become a natural element of management and all significant meetings in Skanska Talonrakennus.

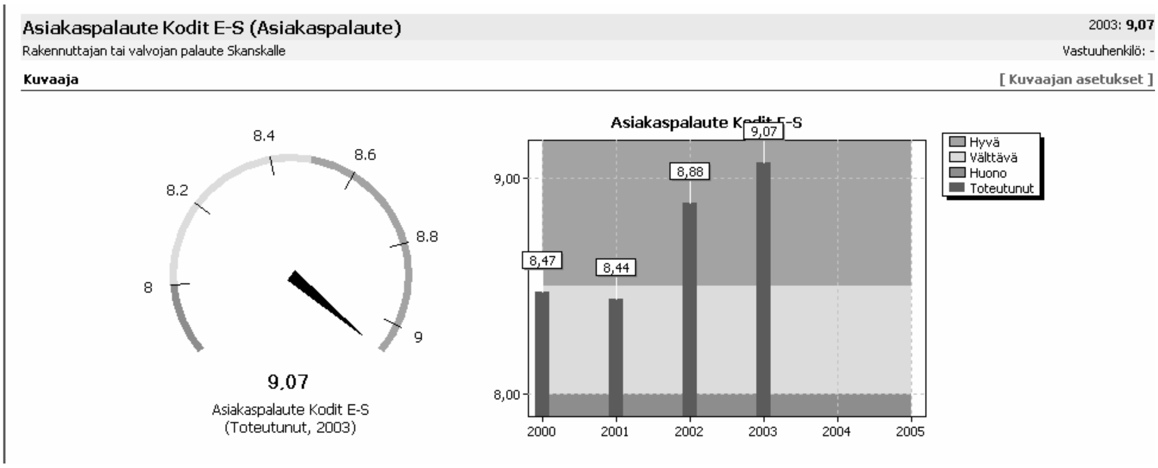

Figure 5. View of the indicators.

5. Critical Factors for the Reform of the Management System

Reform of the management system of Skanska Talonrakennus was an interesting project where many critical aspects and goals were implemented successfully. On the other hand, there is also still room for learning and improvement.

Since we had to deal with a matter new to the organization and even theoretically challenging, there was a risk that the work of fifteen process development teams would lose miss their guiding principles, and the result would be heterogeneous. The implementation of the selected phase-based process theory was, however, quite disciplined, and the result was a logical system.

Customer-oriented definition of processes proved to be a good way to learn understanding the customer’s expectations and call to question the conventional practices of the company, which were the result of the functional system. Reception among customers has naturally been very good for an management system of this type.

Appointments of people were successful. Process owners remained active throughout the project. Another essential factor were the intermediate goals set for the project at intervals of roughly two months, and the owners complied with these goals. Their enthusiasm about the process approach and their good position in the organization facilitated the introduction of the system significantly. The duty of the process owners also in the future is to improve the system to ensure that it generates value to customers as efficiently as possible. As the implementers also managed to create a relatively simple, modern system that makes work more efficient, its use was also preferred compared to the old system.

Measuring indicators were extremely successful in improving the quality of reporting. However, their content still requires a lot of improvement. Most of the indicators measure more the outcome than the true efficiency of the process. There are also some indicators in the measuring system whose real useful exploitation has not yet been confirmed.

Although the entire personnel was trained to adopt the process approach and the new management system, training has not yet been sufficient. Training on process contents needs to be increased. Also basic system training must be continued even to other employees, not only newly recruited personnel, because the using skills differ between the regional units. The level of skills is better in units where personnel has had the possibility to practice on their own the basic characteristics of the system in computer classes than in units where training was given in the form of lectures.

6. Conclusions

According to the experiences of Skanska Talonrakennus, process approach is a good way to model, manage and improve project-oriented construction operations. Provided that the process model is kept sufficiently simple, it supports prioritization of activities and development of critical success factors. The process-based management system helps understand the ensemble of all operations.

In the initiation phase of the project it was estimated that taking the process approach through an organization of this size would require five years of work. Now we are about halfway through that time, and a lot still remains to be done. For instance continuous improvement of processes has only begun, and the heritage of functional approach still shows even in planning of operations.

In 2005, resources will be allocated particularly to training events and reference material of the system. Some of the reference material is relatively heterogeneous and outdated, copied from the previous system. Improvement of the usability of reference documents is going on.

This year we will also introduce a new system tool for collecting and analyzing of safety findings. All findings relating to industrial safety at the sites of Skanska Talonrakennus will be recorded in the system. The idea is to have a good system that will activate the entire personnel into improving industrial safety.

Extension of the system to strategic planning, definition of individual user profiles and integration to other Skanska systems are some of the potential development targets.

The quality of the new management system can for the time being be evaluated mainly on the basis of employees’ comments and changed management practices. On the basis of their positive nature we have reason to believe that the reform of the management system has been a significant step in the right direction, and that the new system will from now on provide good support to Skanska Talonrakennus in achieving its strategic goals.

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Project Management as a Synergic Competence for a Construction Corporation

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Abstract

Corporate synergy and construction project management (CPM) as a synergic competence are discussed as the two challenges in the context of managing a multi-service corporation in construction. First, a main contractor (as an internal client) and a sub-contractor are trying to meet their own project goals separately. In turn, the goals of two units are seen as the common one in the eyes of corporate management. Herein, the latter can enhance profitable synergy through both (a) hard values such as the scale of economies in procurement contracts and (b) soft values such as shared client relationships, joint development teams, and shared know-how. Ultimately, corporate management gives the guidelines for solving this internal partnering dilemma, i.e. ensuring the competitive price/cost and high productivity in each project. Second, CPM is herein perceived as one of the synergic core competences of a construction corporation. Thus, corporate management guides the advancement of CPM skills, common language and sense of responsibility among key personnel across all the related businesses and units.

Keywords: Construction, cooperation, internal partnering, project management, synergy

1. Introduction

Herein, **the management of a construction corporation** is approached, in particular, in terms of solving the two internal problems that are typical in corporate settings. **The two-fold aim** of this paper is to address (a) the first problem involving conflicts between achieving the real corporate synergy and attaining the project-specific objectives of the two units at the same time, and (b) the second problem which is inherent in enhancing construction project management (CPM) skills as a synergic core competence through all the related businesses and units.

The paper is structured as follows. First, a dilemma of synergic corporate management versus project management responsibility is dealt in light of some relevant literature. Second, the importance of CPM as one of a construction corporation's synergic competences is highlighted. Third, the dual problem is elaborated with reporting on the initial results of one case study. The case firm is one of the largest corporations in Finland, YIT Corporation. In particular, the actual efforts to solve the synergy problem and the CPM competence problem are discussed. Finally, some promising ways for solving the two problems as part of effective corporate management are emphasized.

2. Project Responsibility versus Corporation Synergy

2.1 Converging Goals of Primary Project Stakeholders

In principle, clients (owners) may set very individual goals for their construction projects. However, it is herein assumed that **(profitable) project stakeholders** have many converging goals such as the finishing of the project on schedule and within budget as well as a project is performed without quality deviations and violations against safety regulations. Owners set various goals for their building projects concerning the effectiveness of the procurement process and the performance and the quality of the built spaces and systems. When strategic thinking in real estate evolves, attention will increasingly be paid to creating value-added services for users. The new sources of revenues and the solutions that improve the overall profitability will be sought instead of only minimizing the acquisition costs. At the same time, the scope of a contractor’s duties is expanding as well as long-term partnering and cooperation models are gaining ground. Operational models where both the risks for the investment object in question and the rewards of its successful implementation are shared spur the parties to closer cooperation and innovativeness. Incentive contracts are, after all, designed to line up a contractor’s goals with those of a client by making a contractor’s benefits partly dependent on the results that are important for a client. In this way, a client’s goals become the leading idea driving the implementation of an entire project. [1]

In construction corporations, there are several businesses and units that together create an extensive construction service provider. When one of a corporation’s main contracting units is selecting a subcontractor, a natural choice would be the use of in-house services and supplies. In this internal case, both an external client and corporate management expect flexible and profitable cooperation between a corporation’s units that are engaged in an external client’s project. Typically, an external client and an internal client are both expecting to get high quality and functionality at the targeted (minimum) cost (Figure 1).

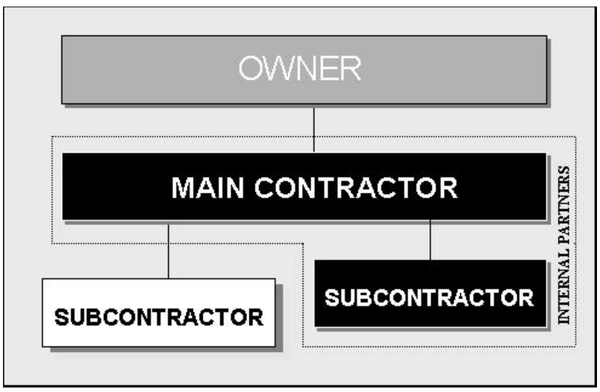

Figure 1: Converging project goals of the external and internal clients of an internal subcontractor (in the case of a construction corporation).

2.2 Procurement Dilemma

In many EU countries, the most common competitive bidding methods (related contracts that eliminate flexibility) and payment rules do still prevent from attaining any higher or broader goals beyond the project-level ones. This practice is coupled with one key task of a project manager, i.e. to finish his/her project within budget and, preferably, to maximize profits. Even in the focal corporate setting, a project manager is usually authorized to procure freely in order to attain the project goals and, thus, a corporate profit is beyond his/her direct concern. A cost-focused project manager drifts to select subcontractors and suppliers through a traditional competitive bidding, which means that an internal unit has to compete with external competitors. In addition, an internal unit is struggling both to fulfill the contract(ed wishes) of its client(s) and to meet its own financial goals, typically, by optimizing the resource uses and implementing everything within the necessities only. Thus, it seems that traditional project management and procurement behavior are together one of the root causes for a procurement dilemma, i.e. diverging project goals and contractual disagreements occur frequently also inside construction corporations.

2.3 Appropriate Internal Procurement

Appropriate procurement is dealt with **in the case of an internal client** as follows. It is assumed that an external client will first select one unit of the focal construction corporation as the main contractor. In turn, this main contractor faces a dilemma of using one or several “sister” units according to the corporation’s procurement policy. How is this internal client to choose the unit that is appropriate, competent, and trustworthy? Herein, only a few of Winch’s principles of resource-base selection are briefly applied to appropriate internal procurement. Typically, service contracts assigned in the early phases of a project, principally associated with design, face higher uncertainty than those assigned later, principally associated with execution on site. It is argued that also internal clients can consider **the four ways of procuring construction services** as follows [2] (Figure 2):

- An internal capability is maintained. This option involves a traditional choice of make or buy. In construction corporations, a true in-house service is regarded as a cost centre only.
- An internal subcontractor or supplier is appointed. In conditions where there is not enough information to allow the preparation of tender documents, the appointment of the internal party based on a list of references for having previously completed similar projects is a viable option. Appointment may also be used when the requirement to mobilize the resources for execution on site is urgent. Internal partnering may become very similar to appointment.
- Concours like procurement can be considered, in particular, concerning design services. The essence of a concours is that competition is based around the quality of a solution offered to a client’s problem, rather than its price.

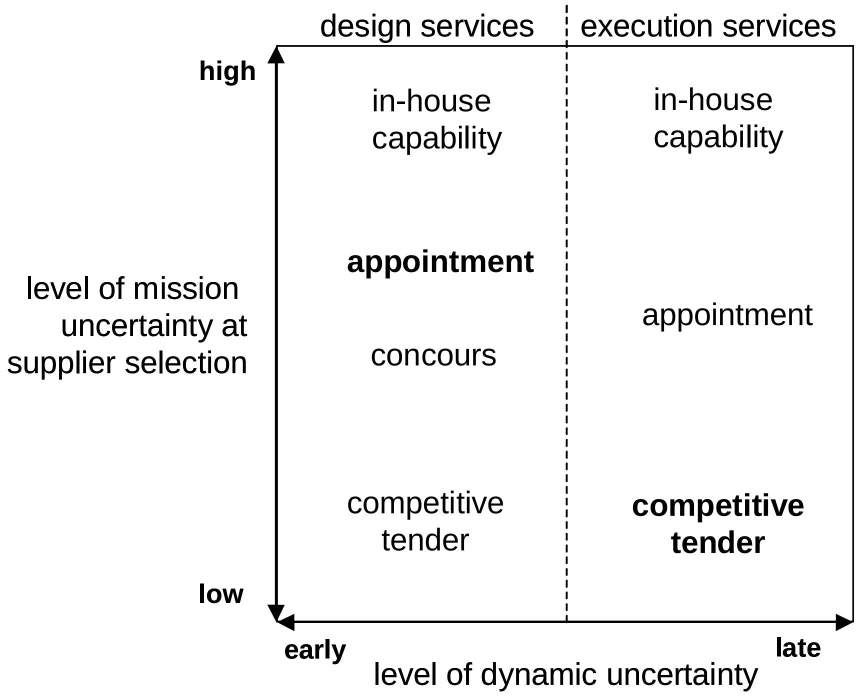

Figure 2: Alternative supplier selection methods (methods in bold are the most common per phase) [2 p. 102]

- Competitive tendering is a plausible basic option for selecting internal subcontractors or suppliers in corporate settings. It is distinguished by the formalization of both the selection process and the criteria upon which the final decision is made. However, competitive tendering often colludes with the idea of corporate synergy.

In broad terms, **the appropriate form** of resource base selection is a function of the level of uncertainty in the specification of the resources required at the time of selection. In particular, the level of mission uncertainty and the phase in the project life cycle are taken into account. [2] In addition, corporate management deals with an economic trend (high, boom – low, depression). During the low economy, it is more in the overall interest of a corporation that internal client-ship works. During the times of boom, it is evident that many possibilities exist to gain higher profits by procuring from supply and service markets.

2.4 Transfer Pricing

In a large construction corporation, management cannot monitor and control all the operation parameters of every unit. For this reason, corporations are organized as a set of divisions. Corporate management aims at coordinating divisions in ways that maximize the total profit. However, each division is still fairly autonomous and its head may have a freedom to take all the actions perceived necessary. Therefore, corporate management meets **a difficulty in evaluating and comparing division-specific performance**. In order to evaluate the performance of each division, several methods may be used for trying to measure the contribution of each division to the total profit of the corporation. One common way is to set transfer prices for internal services, goods, and outputs which are transferred from one division to another. The alternative **transfer pricing methods** are as follows. [3]

The market price is used as a transfer price, if there is a market for an intermediate service price. Often a transfer price is the market price minus the selling expenses. In **a dual price method**, the price that the selling division receives is not equal to the price that the buying division pays - and is usually higher. This mechanism generates a deficit, which corporate management sets off by an optimal transfer price and, hence, the optimal transaction volume, which in turn yields higher performance than other methods. Indeed, this method requires corporate management to be involved in a complex process of price-setting. **Negotiated transfer price** is reached between the relevant division managers. The advantage is that it preserves the divisions' autonomy. Its problem is the sensitivity of the outcome to the managers' negotiation skills. **Resale price** is used when a corporation purchases goods from internal units and resells them to external parties without any value additions being made. The arm's length price is calculated by deducting the gross profit from the resale price on the goods sold.

The cost plus method can be employed when there is a transfer of semi-finished goods between internal units, joint facilities are arranged, or services are provided. A cost base for both a comparable company and the one under review must be carefully analysed to ensure that the costs to be marked up are consistently defined.

Under **the profit split method,** the combined profits, which are the total profits from the controlled transactions, will be apportioned between the internal units based upon the relative value of the functions performed by each of the parties in the controlled transactions. Where two or more transactions are interrelated, it may not be possible to evaluate them on a separate basis. This method seeks to eliminate the effect of special conditions on profits by determining the division of profits that independent parties would have expected to realize from engaging in the transactions. The method can be used when there are no comparable transactions between independent parties. Under **the transactional net margin method**, the profit levels of similar firms serve as a guide to help determine the arm's length price to be applied to the transactions between two or more internal units. This method looks at the net profit margin relative to an appropriate base (e.g. costs or sales) that a tax-payer makes from a controlled transaction. [4]

In general, the use of transfer pricing is an effective way to allocate resources. In construction, transfer pricing seems to be used seldom. Herein, transfer prices are seen as a viable tool when the overall solution is sought for a procurement dilemma within construction corporations.

2.5 Corporation Synergy and Internal Partnering

The basic idea of **corporation synergy** can be described by an equation of 1 + 1 > 2. A construction corporation should be more profitable and effective than each of its divisions alone. It seems that **internal partnering** is one of viable ways of achieving corporate synergy. [5] Or, if you are not partnering internally - communicating with your colleagues, your members and customers; working as an integrated client team - then it is unlikely that you will successfully partner with external organisations. [6] There are many advantages to be exploited but cooperation cannot be taken for granted. In particular, internal partnering forced by corporate management is leading nowhere. Herein, a set of alternative ways of achieving corporate synergy is compiled. This initial list consists of ways coupled with **hard values,** i.e. benefits that are (fairly) easy to measure as follows (Table 1, the left column):

- Vertical integration consists of benefits available from managing contractual business relationships between internal units, with the goal of improving capacity utilisation, price realisation, and market access.
- Economies of scale can be achieved in several construction processes or functions both through increased project volume and internally benchmarked learning.
- Combined new business creation can be based on the utilization of know-how within several related units and the extraction of activities from these units and the establishment of a new unit as well as internal joint ventures or alliances.
- Shared tangible resources may involve achieving benefits through economies of scale and the elimination of duplicated efforts when physical assets and resources are shared, e.g. two or more business divisions are using the same manufacturing facility or research laboratory.
- In procurement, the pooled negotiation power of the corporation comprises the cost or quality benefits that can be gained typically from the bigger scale. It can also be extended to achieve many benefits through joint negotiations in various transactions with other stakeholders such as customers, governments, and universities.
- Coordinated strategies enable to reach for benefits that arise when the strategies of two or more businesses are aligned. For example, internal competition is avoided or reduced between units (e.g. allocated markets). Similarly, the competitive reactions of two units are coordinated against shared competitors (e.g. multi-point competition). [7]

In practice, the value of many operational synergic benefits is difficult to measure. The potential of **these soft values** is inherent in trust, avoidance of litigation, common values and rules, and the use of the outcomes of shared development projects (Table 1, the right column). Typically, shared know-how covers the benefits associated with the sharing of knowledge and core competences across the business portfolio. It may involve the sharing of best practice in certain business processes, the leveraging of expertise in functional areas, or the pooling of knowledge upon how to succeed in specific geographical regions. The know-how may be written up in manuals, policies, and procedures. In many cases, know-how is less formally documented, i.e. it is a dilemma of sharing the implicit, tacit ways that skilled managers master.

On the other hand, **an equation of 1 + 1 < 2** is not unknown. In construction corporations, there are typically internal obstacles that more or less prevent corporate management from mobilizing the huge potential of internal synergy and partnering. In practice, when internal units are unable to operate as a single project team, the resultant performance is probably lower than the level they would achieve under a contractual relationship between independent parties. Typically, the economies of scale are seldom achieved fully. In many cases, internal divisions are too autonomous. In other words, each division is simply focusing on the minimization of its costs and the maximization of its profit. [5]

Table 1: Alternative ways of synergic performance within a construction corporation.

MEANS FOR SYNERGY	
Hard values –benefits are easy to measure	Soft values –benefits are difficult to measure
• Corporate management • Economies of scale • Combined new business development • Synergic software • Shared human resources • Marketing (e.g. corporate brand) • Shared space (e.g. office building) • Procurement (incl. also personnel related procurement) - company telephone subscriptions - vehicle leasing policy - etc.	• Cooperative leadership • Organization • Joint training programs • Personnel rewarding methods • Shared customer relationships • Joint development teams • Shared know-how • Shared company values and policy • Trust • Avoidance of litigation

3. Construction Project Management (CPM) as a Core Competence

3.1 CPM as One of Corporate Competences

Herein, the management of a construction corporation with **a capacity to remain balanced** through the conflicting demands of the daily operations of the units is seen as a significant achievement. However, the strategic use of core competences does not end at the boundaries of the focal corporation. Rather, a corporation that uses core competences as an avenue to focus on growth opportunities must also focus on the external market. In targeted markets, the strategic focus transfers from keeping the corporate units directed toward a balanced system to retaining a cohesive focus in relationships with external clients. At the first level of this external focus is each external client. Paralleling a focus on internal activities, an external focus on clients is needed to pursue individual clients or projects that fit within a corporation's strengths. Retaining this client focus is a central component of a core competence concept. [8]

Construction project management (CPM) consists of a management system and personnel's individual skills. The key is to place individual competencies into a proper pattern that builds the corporation into a set of dynamic units that are capable of moving beyond their current focus and limits. [8]

3.2 Characteristics of an Effective Project Manager

Traditionally, **CPM** is emphasized in terms of management systems. CPM focuses on planning, controlling, and other management functions. Luckily, the effects of human actions in project processes are being guided more and more. Even in projects with technical challenges, a technical competence is not the factor that makes the difference between effective and bad project managers. It is vital that a project manager is capable of interacting and communicating while managing project processes and tasks. Herein, **the five key characteristics** of an effective project manager are put forth as follows: (1) do explain complicated things simply, (2) do not panic in difficult situations but stay calm and find a step-by-step way forward with the CPM team, (3) do face up the problems, find out causes, and make proposals to remove them, (4) do let people know what is happening all the time, and (5) do keep in mind the big picture of the project environment while performing the project processes and tasks. The criteria for a project manager's success involve factors having to do with both a manager's characteristics and project results. The former are clearly split between the two aspects of management: production-orientation and people-orientation. [9]

3.3 Problematic Variation of CPM Skills between Internal Divisions

In general, **everyday CPM problems** on construction sites are well-known: too little time is spent on CPM both in planning and execution. This is resulting in difficulties in holding project schedule and budget. One barrier for fluent cooperation between contractors involved in the same project is a lack of common language, policies, and CPM skills. Communication and information sharing between the project manager of the main contract and the ones responsible for the subcontracts is vital. When CPM information is not shared effectively, a large number of problems are emerging on sites. Herein, it is argued that **the variation of CPM skills** is large also within construction corporations, between international divisions, in part due to variations in educational background and corporate culture. On the one hand, divisions assuming a role of a main (principal) contractor in projects are well equipped with CPM competences. On the other hand, divisions acting as subcontractors seem to possess more technical competences (e.g. HEVAC) and less CPM competences. A lack of CPM skills causes problems in coordinating schedules, communicating between project actors, and actually leading specialty works.

4. Case YIT

4.1 YIT – Finnish Multi-Service Corporation

YIT is the leading Finnish-owned construction corporation which is also engaged in extensive international operations. YIT offers technical infrastructure investment and upkeep services for the property and construction sector, industry, and telecommunications. In all these sectors, YIT's services cover the entire life cycle of investment objects (projects). **YIT Corporation** is managed along its four businesses: building systems, construction services, services for industry, and data network services. The corporate organization consists of four subsidiaries, respectively. In tens of projects, **the subsidiaries** of YIT are acting together through contractual relationships. Typically, Construction Services Oy operates as a main contractor and Building Systems Oy (with HEVAC services) as a specialty subcontractor. In addition, the role of Data Networks Services Oy is growing in internal contracting in the future.

YIT is **a project-driven organization**, i.e. various projects (contracts) are the most important sources of revenues. (Construction) project management is thus seen as a core competence for YIT. Each project involves several contractors in these project-driven businesses. Each contractor is dependent on each other's schedules and milestones. So it is assumed herein that effective cooperation between contractors requires the same kind of (C)PM skills (Figure 3).

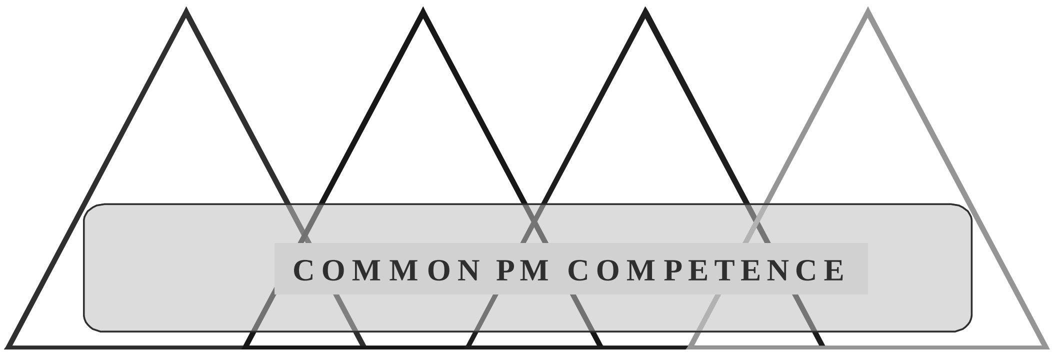

Figure 3: YIT's four businesses with their distinct spearhead competences and (C)PM competence as a common core competence of corporation

4.2 Questionnaire Survey on CPM Training Needs

Within YIT, **the questionnaire survey data** is being collected on a regular basis to get better understanding of the need of CPM training in the future. A questionnaire has certain advantages compared to an interview, e.g. hundreds of people can be reached at a relatively low cost. Respondents are given a possibility to answer anonymously. CPM is divided into 17 areas based on the literature and the accumulated experience within YIT. The CPM areas are considered as rational internal training modules (Table 2).

Herein, it is reported on the results of the recent surveys among the personnel who participated in YIT's internal CPM training during the last quarter of 2004 and the first quarter of 2005. The 149 respondents include project managers, project administrators, cost estimators, and middle managers in both the corporate offices and the regional offices in Finland. The questionnaire included one major question: **In what kind of CPM training are you willing to participate in the future?** Overall, the results are a bit surprising, i.e. 65 % of project personnel desire for deeper knowledge on project cost management, nearly 50 % time management and scheduling, and nearly 40 % contractual matters. Thereafter, project planning, design and engineering management, and project handover process are also highly scored (Figure 4).

In terms of **YIT's three businesses**, 46 % of the respondents belong to Construction Services (CS), 39 % Building Systems (BS), and 15 % Data Network Services (DNS), (Figure 5). Within both the CS and BS, the CPM interest of the personnel is fairly high. The two distributions are surprisingly near each other despite a few differences (e.g. design and engineering management). Broadly, the high needs for CPM training seem to indicate that some past conflicts of joint projects may have been caused by a lack of proper CPM culture. The lower rates of the CPM interest within DNS may be due to the different nature of this third business.

Table 2: Seventeen modules of CPM training within YIT.

1. Project Time Management and Scheduling	10. Management of Life-Cycle Issues
2. Project Cost Management	11. Design and Engineering Management
3. Contract Management	12. Environmental Management
4. Risk Management	13. Cost estimating and bidding/tendering
5. Procurement and Logistics Management	14. Customer Relations Management
6. Project Planning	15. Project Handover Process
7. Internationalization and Language Skills	16. Safety and Health Care
8. Site Management and Quality Management	17. Leadership training
9. Project Data Management and eService records	

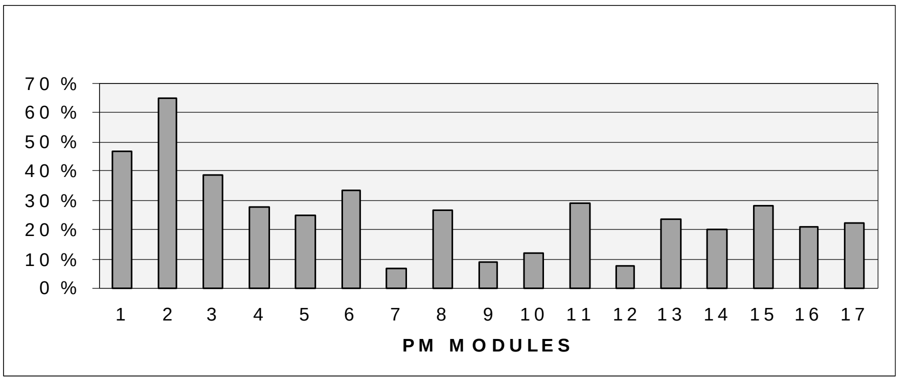

Figure 4: Total rate of interest in CPM training modules within YIT around a turn of 2004/05.

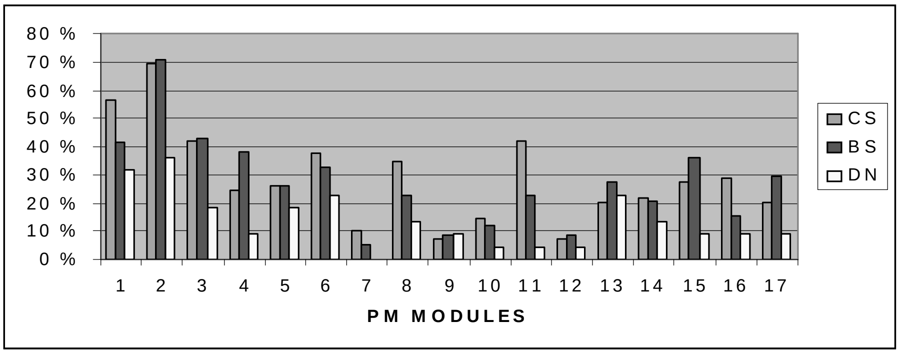

Figure 5: Rates of interest in CPM training modules in YIT's three divisions around a turn of 2004/2005

5. Conclusions

In this paper, the two issues within effective corporate management are addressed, namely, managing a corporate synergy despite many barriers and enhancing CPM skills up to a synergic core competence of a construction corporation. In principle, corporate management should thrive on **corporate synergy** especially when economy is down. In turn, corporate management may allow the outreaching for higher profits during booming periods. The corporate goal is to grow the synergic businesses, not only to share the contracted total profit. In the case of YIT, a potential of corporate synergy is high due to the relatedness of its four businesses. However, this kind of business portfolio is vulnerable to a risk of two businesses going down at the same time at least in one of YIT's primary markets.

In concepts of **partnering**, cooperation and the search of common goals are praised. In practice, real project life is more complicated than these concepts let us assume. "Project (wo)man" operates fundamentally with her/his own interests and this tendency needs to be taken into account when planning internal partnering and synergic joint projects. For example, project goal-setting can be done jointly by the internal project managers. No single project manager (team) should be left alone with less (when her/his/their colleagues are gaining more) without the compensation in one form or another. At the end of the day, other ways of seeking after higher profits through corporate synergy, i.e. ways that are not directly related to projects may remain obscure in the minds of CPM teams.

For construction corporations, **some conditions of effective internal partnering** are suggested as follows. Every partner (unit) acts on a truly profitable basis. Market price seems to be the only encouraging pricing method. Negotiated price is also possible. The competitiveness of each unit needs to be measured also against the direct external competition in terms such as quality/price ratio on an annual basis. An "open book" cost model and a flexible, open frame contract are used to create and maintain trust. Some elements of internal competition are preserved. Through a chain of projects, cost efficiency, time-saving scheduling, and team spirit should be advanced. In addition, the internal partners need to act as the seamless front in the eyes of primary external clients (owners). In the case of YIT, the principal contractor and the HEVAC contractor are obviously aiming at the flawless contract fulfilment with each external client. In the future, these subsidiaries could analyse a potential of the resale price method and the one of the profit-split method.

Finally, **CPM** is herein advocated as one of core competences within construction corporations. In practice, the effectiveness is highly dependent on personnel's CPM skills. Also the enhancement of high, balanced CPM skills across the corporation is one of the conditions for profitable synergy. [10] In the case of YIT, the survey results indicate that the personnel are aware of their needs for higher CPM skills. Obviously, one of the ways to advance CPM as a synergic core competence involves the hands-on training and learning by accomplishing more demanding CPM tasks under professional guidance.

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Construction Project Cost Management Tools In-use: a UK Perspective

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Abstract

The effective control of a construction project budget from project inception to completion and occupation is one of the primary tasks of any organisation employed to deliver construction project management services irrespective of the projects actual global location. This paper sets out the key issues and problems involved in the delivery of this service to construction industry clients in the UK.

The main features of a project cost management system are identified in the paper before it addresses the principal problem areas of initial cost budget or baseline setting and project cost performance management. The literature reviewed identifies the potential project management tools that can be used to contribute to the management of each of the principal problem areas. The paper reports evidence collected from previous data collection exercises with practitioners based in the UK that allows current practice to be illustrated. The data on project performance measurement reported in the paper have been collected by mailed survey from one hundred and fifty two organisations involved in delivering project management services in the UK in 2004. The survey achieved a 42% response rate and its results raises questions about the claimed benefits of a bespoke project cost performance management tool termed as earned value analysis. The paper concludes by considering the direction of future construction related project cost management education and the role that can be played by professional institutions to promote change in practice.

Keywords: project management, cost budgeting, cost performance, tools in-use

1. Introduction

The UK construction industry, like others around the world, has a reputation for delivering its projects over budget. The latest high-profile example of this phenomenon is the new Scottish parliament building that, when completed, was nearly ten times over its originally forecasted budget. The Fraser Report [1] on the public inquiry into the project highlighted, amongst other issues, that a poor quality feasibility stage budget estimate and a poor level of cost control provided by the construction organisations involved were to blame for general dissatisfaction with the project. Other high profile instances of such poor performance were identified by Jackson [2] and include projects such as the British Library, Portcullis House, and the Welsh Assembly building. Jackson [2] reports repeated survey work by HM Treasury (1995), the Construction Clients Forum (1997) and the DETR (2000) that have shown clients to be generally dissatisfied with the service provided by practitioners involved in the provision of building project budget stage cost advice and subsequent construction phase cost performance management processes. Therefore the issue of poor project cost management is an ongoing problem for the construction industry and its clients. It is now timely to investigate the processes involved in this business advice function and determine the current state of the art in terms of cost control tools in-use so as to ensure clients' are better able to achieve value for money from their inter-actions with the UK construction industry.

This paper is structured to provide a review of relevant previously published material before it goes on to present the results of data collection exercises with UK based organisations that have enabled a snap-shot of current practice to be established. The paper concludes by considering the direction of future construction related project cost management education and research and the role that can be played in the development of this business service in the UK by professional institutions.

2. Context

Green and Simister [3] cite Hammer and Champy's (1993) definition of a business process as being, "a set of activities that, taken together produce a result of value to the customer". Currently, the processes used in the construction industry to deliver its clients' projects are being subjected to a period of re-design and accelerated change to ensure that they deliver greater value for money. Increasingly the assessment of value-for-money is being considered from a broader perspective that includes social, environmental, and economic features [4]. Winch and Carr [5] maintain that this the generation and communication of reliable early stage project budget estimates and the implementation of effective project cost control measures that are related to the construction and commissioning of building assets are sub-processes within their standardised project related process map. As such it has been asserted that industry would benefit from their further development and as a result of actually using the output of research. Similarly, the generic design and construction process protocol developed by Kagioglou *et al* [6] also indicates that such business activities would be considered as a sub-process within their model, namely the feasibility stage of a project's pre-construction cycle and the project's construction cycle. It can be seen that effective construction project cost management processes are a fundamental component in any project's value appraisal system.

Kerzner [7] and Lock [8] amongst others, identify the principal components of a construction project's cost management process as being; the establishment of a realistic budget, the determination of a system of work authorisation and release, the collection and analysis of timely performance cost data across the project lifecycle, the establishment of effective cost change management systems, and the creation of meaningful cost account and variance reporting mechanisms. This broad analysis has a strong relationship to the main components of a cost control process set out by the Project Management Institute (PMI). The PMI indicates in its body of knowledge (BoK) that its cost management processes are concerned with creating what it terms as being a project cost baseline as well as managing changes to the cost baseline. For instance the PMI [9] indicates that the main features of such a project cost control system need to address cost inputs, the tools and techniques used to assess performance and the cost reporting mechanisms used to provide timorous information to decision makers. There seems to be broad agreement on the principal components of an effective project cost management process. As a result this paper addresses two features of any cost management system namely, the building project baseline budget estimating processes and then secondly, the tools and techniques used to assess the cost performance of the project during its production phase.

2.1 The Building Project Baseline Budget Estimating Process

Skitmore *et al* [10] considered pre-tender budget price estimates which within the construction industry form the project cost baseline position and asserted that the 'dominating presence of uncertainty in the construction process militated against the production of accurate estimates by numerical analysis alone'. As a result building project budget estimating must involve a mixture of calculation and judgement. In order to develop an understanding of how building project budget estimates may have their quality enhanced it is necessary to identify the processes involved. Bowen [11] developed a communications based theory of building project price forecasting. That model was based on the Shannon and Weaver's linear or process model of communications and it indicated a major divide in the process between the phases of forecast formulation and forecast transmission. The formulation phase of this theoretical process was divided into iterative cycles of investigation and application. There remains a need to fully investigate the construction project budget estimating process as a means of addressing the performance gap of practitioners that can result in the incidences of inadequate business services indicated above in terms of poor quality project cost advice. What is acknowledged is that an essential part the building project budget price advice process is the selection and use of the most appropriate tools or models.

Repeated surveys by Fortune and Hinks [12] and Fortune and Cox [13] have established the 'state of the art' in terms of building budget estimating models in actual use in the UK. In general these large-scale empirical studies have found that there were over twenty models currently in-use. The results of the surveys show that in general terms the paradigm shift towards the newer non-traditional models, called for by academics such as Brandon [14], has not been generally achieved. What can be seen is that the results of successive waves of the prevailing engineering or product or tool centred research that has been funded by government grant has not been found to be useful in practice. Examples of such an engineering or product-related research paradigm are the knowledge-based models, the regression models, the whole life cost models, the fuzzy logic and neural network models, which have been developed over a period by academe for the industry to use. The repeated surveys show consistent evidence of low levels of usage of such models and the continued overwhelming use of manual, deterministic models that have been found to formulate inadequate cost advice over a period of time. Latterly there has been much research effort directed to the development of models or tools that can take account of the sustainable impact of proposed projects. The survey work reported in Fortune and [13] again reveals that such tools have not yet been adopted for widespread use in practice. Given the slow rate at which changes in practice can be achieved in the construction industry then it is too soon to suggest that these new models that address the assessment of sustainable impact of projects have been abandoned by practice. However, the same cannot be said for the paradigm change called for by Brandon in 1982. The results of the research reported above indicate that such a paradigm change has now been abandoned by practice and as such this finding will have implications for the education and training of future professionals.

2.2 Construction Phase Cost Performance Tools In-use

Lock [8] considers that the emphasis given to project management cost control is unique in the UK construction industry due to the existence of quantity surveyors and detailed bills of quantities. As a result the standard tools suspected as being in use in the construction industry to manage the construction phase project cost performance management process included milestone monitoring, variance analysis, valuation analysis and standard s-curves. Milestone monitoring uses predefined stages or phase completion of projects as the trigger mechanism for contract payments to be made. Lock [8] indicates that the data required to set up the milestone approach to construction project cost control are the project schedule or programme and the budgeted cost of the activities required to be completed to achieve the milestone. A potential drawback to the use of this approach to production cost control is the re-active and delayed nature of information availability. The cost information generated by this technique takes no account of the actual work achieved on site and assumes one hundred per cent efficiency of site operations. However, Abdomerovic *et al* [15] do acknowledge that the great advantage of using this approach is its simplicity and resource efficiency in operation.

The use of variance analysis as an approach to construction phase project cost performance management acknowledges that changes are endemic on construction projects. Ronald [16] asserts that this approach can be used to highlight the inefficiencies caused by such changes in terms of their cost consequences on the project's baseline budget figure. Pilcher [17] argues that this technique is well suited to construction project production phase cost control due to the prevalence of bills of quantities but nonetheless it is generally accepted that such a system is itself costly to set up and does not focus on overall project costs. The valuation analysis approach was asserted by Walker and Wilkie [18] as being the most popular in-use. This approach calls for the practitioner to carry out valuations of the work executed on the project at the end of a given period. Such an approach provides data for the contractor to use in benchmarking performance against payments received for each of the resource centres required for project production, namely. labour, materials, plant, and sub-contractors. However, Pilcher [17] points out that the approach can lead to inaccurate data and that often contentious items are excluded from timorous payment although resource has been expended in their execution. In addition this approach does not facilitate the forecasting of overall project costs. This is a claimed advantage of the S-curve approach to providing construction phase project cost performance management. This approach provides data against the formation of standard cost curves for the project. Such curves are usually s-shaped and are derived from data from previous similar projects. Control can be achieved by plotting actual expenditure against budgeted costs on a periodic basis. Galley [19] pointed out that the main flaw with this approach was that the s-curves produced could indicate performance gaps but on their own it is not possible to say whether the project is behind or ahead of the planned schedule.

Wake [20] asserted that earned value analysis was an approach that was developed to overcome the combined problems of the conventional approaches to project cost management during the production phase of projects. Support for this position comes from the PMI which indicates that the main tools available to project managers looking to control project cost performance in general include tools such as performance reviews, variance analysis, trend analysis and earned value analysis. Of the tools indicated by the PMI BoK [9] as being generally available it was asserted that it was *"earned value analysis (EVA) in its various forms is the most commonly used method of project performance measurement"*. EVA is based on the combined work breakdown structure (WBS) and the organisational breakdown structure (OBS) for the project being constructed being drawn together so as to develop a task responsibility matrix (TRM). Winch [21] determines that such an analysis can facilitate what he terms as a cost control cube to be formed and that such an approach provides a disciplined framework for the organising, planning, budgeting, measurement monitoring, and reporting of a project's performance.

Fleming and Kopplemann [22] asserted that if EVA was to be implemented efficiently then it was best employed from the earliest stages of the project's development. If this was the case with the use of EVA on construction projects in the UK then it would be necessary for consultant quantity surveyors and other built environment professionals to develop appropriate skills to ensure its application. However, Baker [23] identified that many such practitioners see EVA as being a complex process, which is shrouded in terms, acronyms and formulae that can be intimidating to the uninitiated. On the other hand sources such as Webster [24] asserts that the use of EVA provides a uniform measure for reporting progress on a project and a consistent method of cost performance analysis. The benefits of using EVA as a tool for the measurement of project production cost performance was also given emphasis by its inclusion within the BS6079 and the PMI BoK [9]. Such sources maintained that the use of EVA would allow a more disciplined approach to planning and risk management, as well as providing good programme visibility, and encouragement to the objective and quantitative performance measurement on projects. It was asserted that such an approach would enable timely indications of problems to be developed which would facilitate a more reliable prediction of programme cost schedules.

As this paper is concerned with establishing the tools currently used in practice to manage construction phase cost performance it was now resolved to conduct a questionnaire survey amongst construction project management organisations in the UK. It was determined that the questionnaire should gain measures to determine the current usage of the tools indicated as being available to practice in the literature reviewed above. Accordingly a sample of one hundred and fifty two organisations drawn from both consultant and contractor based construction project management organisations was constructed from the 2003 yearbooks of the Association of Project Managers (APM) and the project management faculty of the RICS. The questionnaire was administered by surface mail and good practice ensured the questionnaire was appropriately piloted before dispatch. Similarly good practice required a covering letter and a stamped addressed return envelope to be included and each form had its own unique reference number that facilitated follow-up in the case of non-response. As a result the survey attracted a response rate of 43% which was considered adequate enough to provide meaningful data.

3. Questionnaire Survey – Results, Analysis and Discussion

Responses were evenly divided between those organisations that classified themselves as being a contractor based organisation and those organisations that classified themselves as being a consultant organisation and these classifications were later used as the principal variables to analyse the data. The first question in the questionnaire asked the respondents to confirm their involvement with construction project management. The results of the question showed that none of the respondents to the survey indicated that that they had no involvement in construction project cost management. This was essentially a checking question that provided data that confirmed the appropriateness of the sample and an indication of the validity of the results. Respondents were then asked to indicate the usual point in a project's lifecycle that they were engaged to provide their project cost management services. The results of the survey have been summarised below in Figure 1. It can be seen that generally respondent organisations start to provide their project cost management services during the pre-construction phase of a project's delivery cycle.

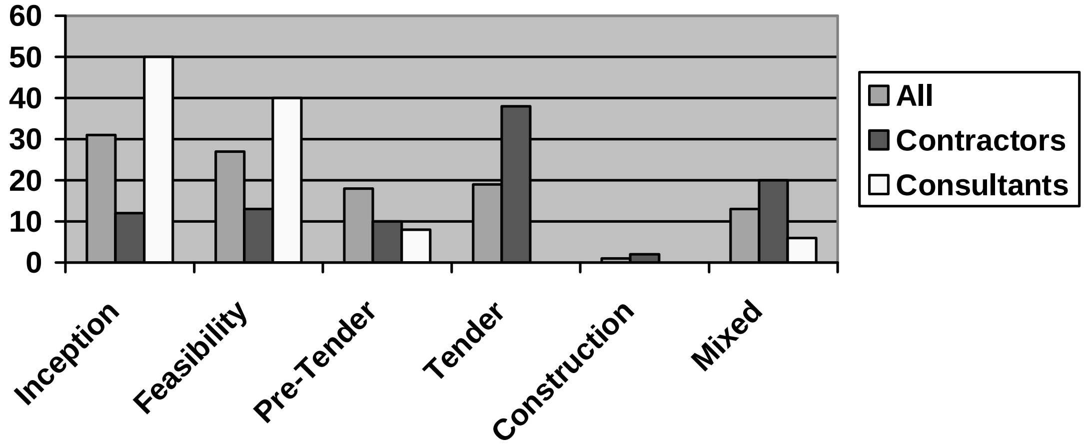

Figure 1: Project Cost management services and the project lifecycle

Figure1 shows that there is difference in approach between consultant and contractor based organisations that responded to the survey. It can be seen that contractor based organisations are more likely to start to provide project cost management services to their clients at the tender and construction phases of a project's lifecycle which would reflect the prevailing procurement pattern in the UK. As the changes in the operational practices of the UK construction industry alter following the calls for change made in recent UK government reports then it is likely that project cost management services will be delivered from project inception to completion and occupation. This change in practice should help UK construction industry clients to achieve better value for money from their business investment decisions.

Respondents to the survey were then asked to indicate the project cost control system they were using in practice. Figure 2 provides a summary of the results obtained and it shows that in general the most popular method is the conventional monthly valuation analysis (70%). The other techniques such as milestone monitoring, variance analysis, s-curves and earned value analysis were used by an approximately similar sized minority of the respondents to the survey (15%).

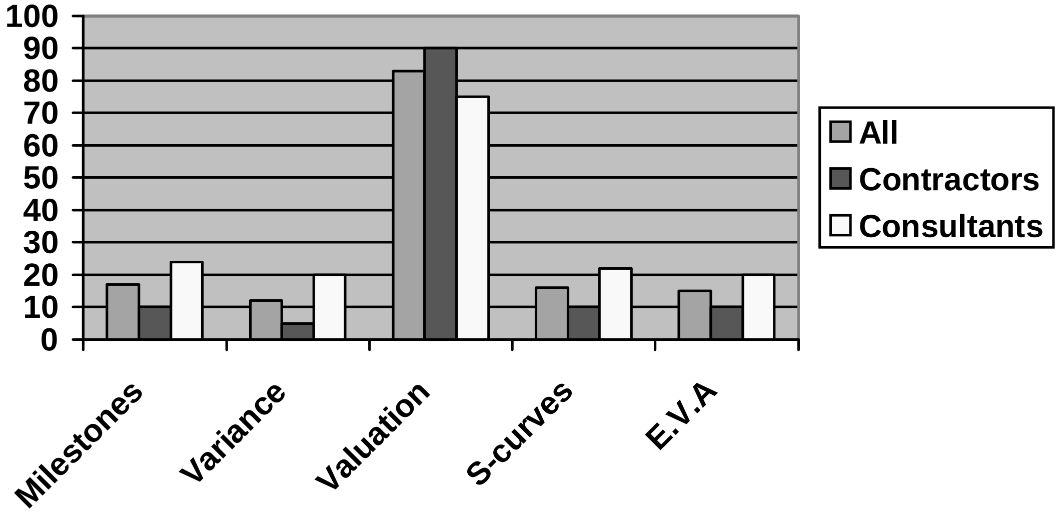

Figure 2: Types of cost control system in-use

This result indicates that the conventional approach to project cost control is still in widespread use despite the claimed advantages of the new wave tools such as earned value analysis. The literature reviewed above indicated that of the newer techniques that were available it was earned value analysis that offered the most to project mangers involved with the provision of cost performance management services. The next question in the questionnaire explored the reasons why the respondents to the survey were not making use of earned value analysis as a cost performance measurement tool. Firstly the respondents were asked to indicate whether they were actually aware of the existence of earned value analysis as a tool to use in project cost control. Figure 3 indicates that the majority of respondents (73%) claimed that they had no awareness of earned value analysis. It can be seen that there was some difference between the consultant (80%) and contractor (65%) organisational types responding to the survey.

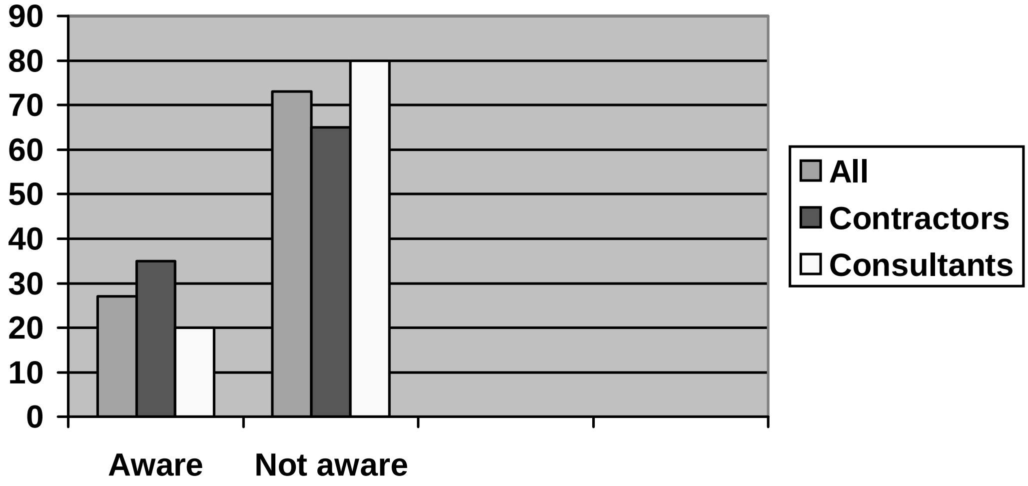

Figure 3: Level of awareness of EVA as a cost control too

This result indicated that contractor based respondents are more likely to be aware of EVA but as revealed above a concern must be that such organisations do not enter the project lifecycle under the tender and construction phases of a project's lifecycle. This late entry to the project was acknowledged to be a real disadvantage in terms of using EVA to its optimum effect. This result also confirmed the finding of earlier work undertaken by Brandon [25] which asserted that earned value analysis was little used in the UK construction industry due a lack of commercial awareness of its potential benefits. This was surprising to Brandon [25] as he pointed out that earned value analysis was indicated as being the preferred tool for project cost control in key documents such as BS6079. However, an earlier survey reported by Fortune and Lees [26] found that in the UK the majority of project managers did not adopt BS 6079 as the co-ordinating vehicle for their project documentation.

The respondents that indicated that they had made use of EVA as a technique to control project cost performance were then asked to give their assessment of the technique in-use in terms of the accuracy of the data it generated and the usefulness of the information it provided. Figure 4 shows that only 31% of respondents that had used EVA found that it was able to generate more accurate data than the other more conventional methods of cost control.

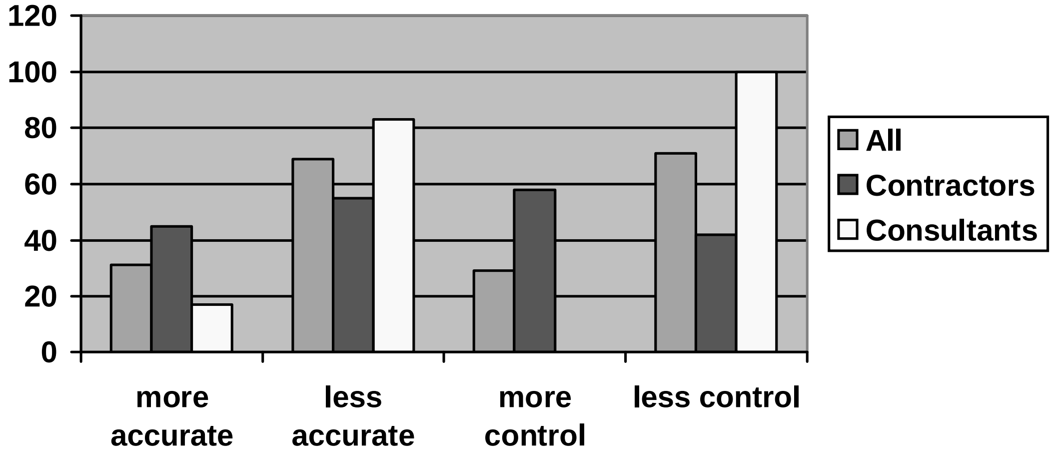

Figure 4: Capability of EVA to generate more accurate data and exercise budgetary control

The results show that there was some difference of opinion between the respondents to this question that were located in consultant and contractor based organisations. It can be seen that only 15% of respondents in consultant and 45% of respondents in contractor based organisations agreed that EVA was capable of generating better budgetary control for their projects. This difference in response was further tested using chi square test and it was found that the difference was not statistically significant. Nonetheless the overall result of this question is in direct contradiction of the finding found in the work of Fleming and Kopplemann (2001) who asserted that the use of such a tool enabled practitioners to generate more accurate data for use in project cost control. Figure 4 also shows that only 24% of respondents that had made use of EVA considered that the technique enabled them to exercise greater levels of project cost control than the other more conventional tools that they had previously used. The results of this question call into question the claims of Wilkens [27] that EVA was a tool that was better than other techniques at keeping projects within established budgets. The results shown in Fig 4 provide clear evidence that practitioners on the ground have not found that newer project cost control techniques such as EVA provide real improvement over their tried and trusted techniques. In such circumstances it is not surprising that EVA is not in widespread use in providing construction project cost management services to UK based clients.

The respondents to the survey that indicated that they had not yet used EVA as a tool for project cost management were asked to indicate the reasons why they had not as yet adopted the method as a tool for use. Figure 6 shows that of the reasons listed, namely cost to set up and maintain, high satisfaction levels with existing tools, and unfamiliarity with the technique. Of the options listed it was found that general unfamiliarity with the approach was the main reason for its non-adoption (58%) and that 30% of this type of respondent felt that their more conventional cost control technique was providing satisfactory levels of service.

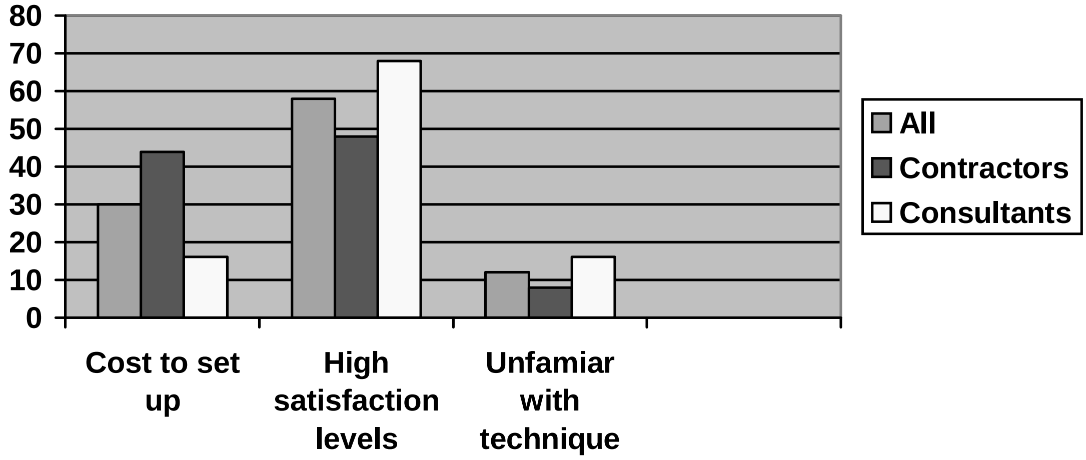

Figure 5: Reasons for non-use of EVA as a cost performance tool

Such results confirm the general level of response generated in response to earlier questions in the survey and provide a measure of internal consistency within the questionnaire which generates confidence in the survey' results.

4. Conclusions

The survey work reported in this paper indicates that the newer tools and techniques advocated by academe for use in UK construction industry for the delivery of project cost management services have so far been rejected. This finding applies equally to the tools used to generate the initial project budget and the tools used to provide data for effective construction phase project cost control. The paper focused on these two key aspects of project cost control as being central features that construction related project managers needed to get right to ensure the effective delivery of project cost management services. The finding in relation to the tools used to set the initial budget for the project is of concern given that academe has been calling for a move away from the conventional tools in-use for over twenty years. Such continued non-use of tools such as regression analysis, probabilistic models, neural models, and neuro fuzzy models raises questions about the effectiveness of previous research paradigms in this topic area. The non-use of sustainable assessment models for projects and the newer construction phase cost control tools such as milestone payments and earned value analysis do not as yet raise the same questions. In terms of the widespread non-use of sustainability models and EVA it is probably to soon to conclude that they have been rejected for use by practice. Rather it points out the time lag that can exist between academe and practice in terms of performance advancement. Nonetheless the survey rejects the findings of other non-construction focused investigations and helps make the case for the approaches adopted in construction related project cost management services to be seen as being non-generic in nature. The lack of awareness of the newer project cost performance tools such as EVA calls into question the effectiveness of the curricula driving courses of formal and informal education. Such lack of awareness also flags up to the relevant professional institutions the need for greater emphasis to be given to this topic in terms of CPD type training programmes.

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Section II

Production Processes and Control

Introducing Last Planner™: Finnish Experiences

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Abstract

The Last Planner method1 represents a radically different manner of controlling production in construction. Even if its benefits are widely observed, it is also a common observation that the introduction of the Last Planner method to a site, into a company or into a country is not an easy and uncomplicated task. This paper reports on the experiences and lessons gained during the introduction of the Last Planner to Finland. A simplified explanation of Last Planner is presented. The experiences and lessons gained are contrasted with those presented in prior literature.

Keywords: Last Planner System, production control, implementation

1. Introduction

During the last few years, Last Planner has been implemented systematically in a number of contracting companies in different countries. The results have been most encouraging in regard to productivity, duration and safety. The Last Planner method represents a radically different manner of controlling production in construction. Even if its benefits are widely observed, it is also a common observation that the introduction of the Last Planner method to a site, into a company or into a country is not an easy and uncomplicated task.

The authors undertook to implement and disseminate this method in Finland since 2003. The goal of this paper is to report of the experiences gained.

The paper is structured as follows. First, the salient characteristics of Last Planner are recapitulated. Then, the first Finnish pilot project is presented, and after that, the learning gained in the subsequent projects. Then, the Finnish manual on Last Planner is briefly described. Next, the simplified explanation of Last Planner is discussed. After considering the present status and prospects of Last Planner in Finland, the concluding remarks are presented.

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[1] Last Planner is a trademark of Lean Construction Institute

2. The Last Planner System of Production Control

Last Planner, developed in the United States in the 1990's [1] [2] [3] is a method for production planning and control on construction sites. Last Planner addresses short term planning and control of operations. The goal is to ensure, through different procedures and tools, that all the preconditions of a task exist when it is started, that the task can be executed without disturbances, and that it is completed according to the plan. The share of tasks completed as planned is monitored on a weekly basis. The reasons for lack of completion are investigated. By influencing the reasons found, an increase of the degree of realization of weekly plans is sought. One further element of the Last Planner method is rolling look-ahead planning, in which the preconditions for tasks are made ready for the next 4-6 weeks. The goal is to maintain a sufficient backlog of ready tasks.

Last Planner production control is based on a new theoretical foundation [7]. Production is conceptualized as flow, leading to an emphasis on reduction of uncertainty and on stemming the penalties of uncertainty. The primary concern of weekly planning is not merely, which tasks should be started according to higher-level plans, but also, which tasks can be started regarding their preconditions. The execution of weekly plans is seen to be based on a conversation, where the responsible person commits himself to the completion of a task as planned. Control is positioned as a starting-point for continuous improvement.

3. The First Pilot Project

The first Finnish pilot project in introducing Last Planner took place in the year 2003. Four major construction companies, YIT Rakennus Oy, Skanska Talonrakennus Oy, NCC Rakennus Oy and Rakennusosakeyhtiö Hartela, each with one project and site took part in the training and testing project. Testing and training lasted for six months on each site.

How did the project go ahead? A detailed theoretical explanation was prepared and it was initially used in training. However, a simplified way of explaining and justifying the Last Planner method for construction professionals was also developed and it turned out to be more effective in training. The training time could be reduced, and justification of the method to managers was made easier.

Training started with a one day teaching and discussion session. About twenty persons involved in site management took part in learning the basic principles of Last Planner and discussing the practices which were to be tested. We also wanted to learn what were the major reasons for difficulties of production planning by making the participants to choose among the following reasons:

- Managing concentrates in control (monitoring) and forgets “making ready” the pre-requisites and resources required to do the work.

- Planning isn’t systematic, but instead it depends only on the ability, skills and motivation of the managers in charge.
- Planning is considered to be same as drawing a schedule.
- The capability of the planning system is not measured.
- When targets and plans are not met, the reasons are not sought and analyzed.

All of the possible answers above were chosen. This shows clearly that the problems of production planning are wide. Solving them requires understanding of the theories, too. In this regard, our one day of training was just a start.

In our site testing we concentrated in

- Making weekly plans, where tasks don’t have any constraints and the pre-requisites are taken care of.
- Getting participants to make commitments in the weekly plans.
- Checking the PPC (percent plan complete).
- Arising interest and starting systematic look-ahead planning, where the pre-requisites for the tasks to be done in the next couple of weeks are realised.
- Finding the reasons and explanations why the weekly goals were not met and also trying to learn from the past to prevent similar difficulties recurring in the future.

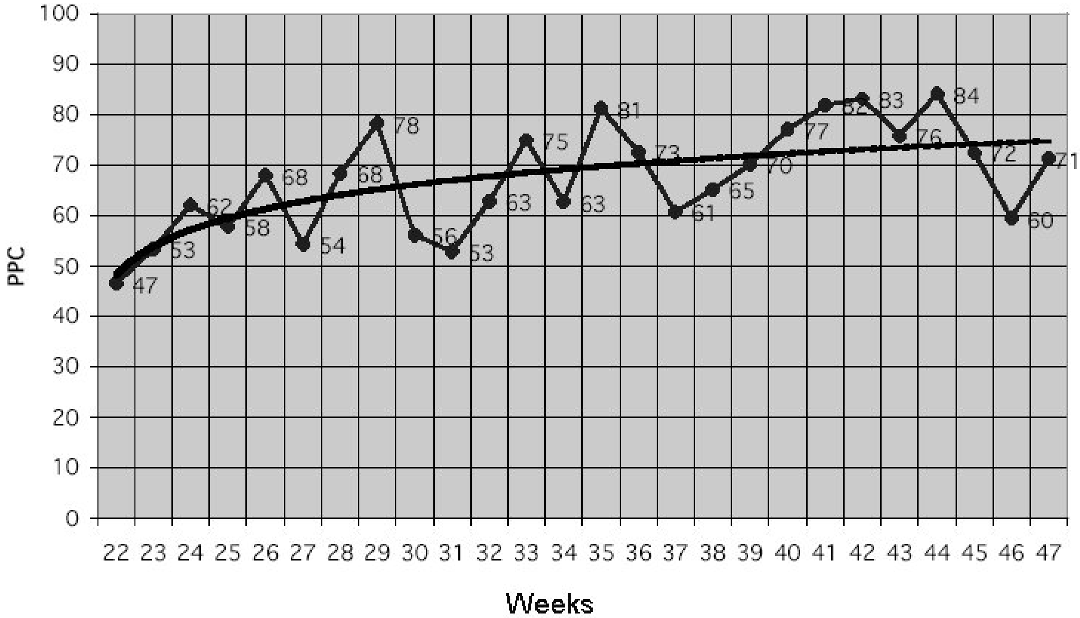

Figure 1. The development of the PPC as an average on all four test construction sites in Finland [8].

The results of the introduction of Last Planner on four domestic construction sites are parallel to those abroad. The PPC got better rising from the average of 47 % to over 80 % before our second day of teaching (Figure 1). After having a day of feedback and benchmarking the intensity of planning and following the Last Planner method probably somewhat dropped.

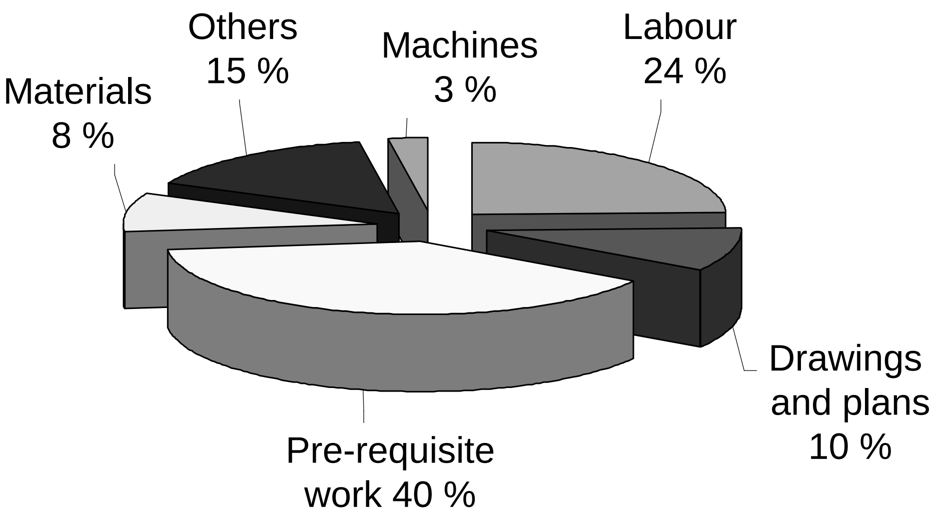

Figure 2 The reasons for non-completion of tasks in weekly plans in the Finnish experiment [8].

The reasons for non-completion of weekly tasks were not those expected. The two biggest groups of reason were pre-requisite work and the labour (See Figure 2). Our test showed that maybe too easily we are looking someone from the outside to blame. Drawings and plans are often said to be the reason for delays and changes. In our test only ten percent of weekly plan failures were due to drawings and plans.

The quality and degree of realization of weekly plans clearly increased. The site personnel considered the method useful especially regarding that the quality level of task ready-making increased and that getting tasks completed in one pass became easier. The quality and quantity of tasks could be controlled, when tasks were clearly defined. This made it easy to measure the productivity of a particular task and its variation. The amount of ad hoc work decreased. The weekly planning sessions made coordination between tasks, workgroups and contractors easier. Also, having reasons for lack of task completion was experienced useful, and it was seen to contribute to the elimination of problems.

Taking the positive results of the experimentation and the foreign cases into account, the implementation of the Last Planner method was recommended in short term production control on construction sites in Finland.

4. Subsequent Pilot Projects

After the first experiment and the report [8] written about it, interest to Last Planner arose among the construction firms. Similar experiments as in the pilot project were conducted in a couple of firms. Some firms made experiments on their own. In the following, related observations and findings are presented.

Phase planning was tested in a middle-sized reconstruction firm. They wanted to get the HVAC-contractors to make commitment to a tight schedule. This was established by making the participants and performers to know each other and collaborate in dividing the building in to parts which can be the basis for phase planning. After that schedules were made in co-operation and committing to one another. A tight four month plan was made to be the basis. Even a great number of changes, as in reconstruction so often, didn’t mess up the phase plan because the promises and commitments were so clear and the tasks due to changes were fitted in with the motivation of keeping the due dates.

The problem with planning ahead seems often to be caused by a failure to plan ahead. Very often the tasks just seem to come from nowhere and we have to start them without all necessary prerequisites. This produces problems in quality, safety and productivity. Although for some managers in Finland it seems to be hard to believe that it is more efficient to wait and make things ready than to just go ahead, lookahead – planning became reality in several projects when a simple worksheet was taken into use (see Figure 3).

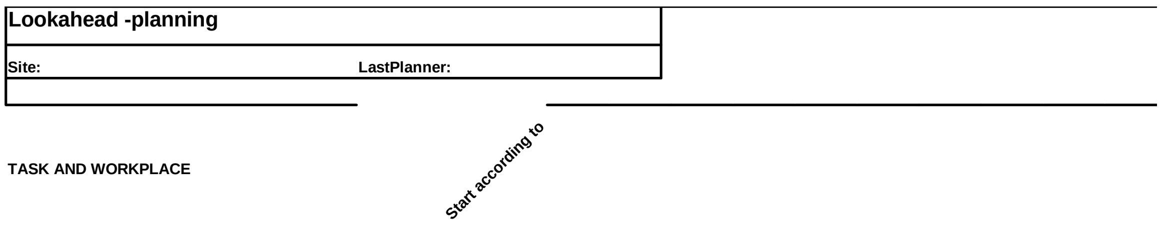

Figure 3. Lookahead –planning spreadsheet on one Finnish construction site.

A belief in the almighty power of the master schedule sits very tightly in the Finnish construction. Master schedules are mainly produced by special scheduling programs on computers. Maybe the colourful, nice looking schedules seem to be something to trust in. In one reconstruction project there were more than 1400 master schedule tasks. So many tasks but very little actual information on task contents, people who are to do the work, with what equipment and even less on commitments. The reality in this project was that the master schedule was of no use.

One key instrument on Finnish construction sites is task planning. It is a systematic way to plan one task from all the production aspects. For example time, cost, quality, safety and pre-requisites are taken into account. Tasks are prepared as whole from beginning to end. Still there is the continuous need for look-ahead planning.

The success in planning and controlling production comes from reliable commitments to the client, phase planning done together, task planning by each subcontractor, rolling lookahead planning and weekly plans into which participants have committed (Figure 4).

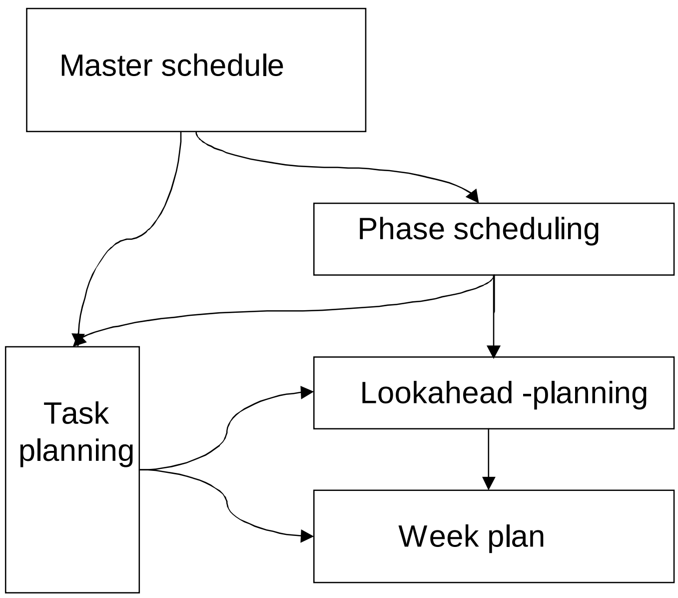

Figure 4. Overall picture of the Last Planner stimulated production planning and control, which is being implemented at the moment in Finland [8].

In view of the first, successful pilot project, the Confederation of Finnish Construction Industries organized a project for creating a manual of Last Planner, to be used both in company training and college and university education. The outline of the resulting manual [9] is presented in Table 1.

Table 1.The outline of the Finnish Last Planner manual.

Koskela, Koskenvesa, Sipi: Työmaan toimiva tuotannonohjaus: Opas Last Planner™ menetelmään. Rakennusteollisuuden Kustannus, Helsinki. 42 p. 2004.

Introduction
Guideline for using and reading this manual
Last Planner production control: why and what?
What is the goal of LP?
The totality of the LP production control
Methods and practices of LP production control
Phase planning
    Why? Basic procedure
    Advanced practice
    Examples and observations
Look ahead planning (this heading and all below in this section have the same subtitles as above)
Weekly planning: making ready
Weekly planning: conversation and commitment
Weekly planning: checking task completion
Weekly planning: finding reasons for non-completions
Continuous improvement
Introduction of the Last Planner production control
Implementation on site when LP is new for all parties
Implementation in a company
Training effort needed
Information technology as a support to LP
Interfacing Last Planner to existing production control system of the company
Higher level plans
Task planning
Further information
References, links etc.

In the manual, the method is structured into seven parts, and the rationale, basic procedure, advanced practice as well as related examples and observations for each part, connected to the overall explanation of the method, are presented. Also the implementation issues are discussed.

5. Explaining Last Planner

In the introduction of Last Planner, there are two challenging moments of explanation and persuasion. First, the method must be sold to the management of the contracting company, so that pilot test can be launched. Second, the method must be explained to the site personnel participating in the pilot test. To some extent, the method can be sold referring to good results abroad. However, inevitably the question emerges: Why is Last Planner more effective than the conventional method? Thus the problem is as follows: How can Last Planner be shortly explained in a plausible way to an experienced professional of site construction? The authors came to think that the explanation must be anchored in the everyday experiences of these professionals.

The observations of Jaafari [5] on productivity in a construction task were taken as a starting point:

> While the size of samples is not large enough to yield conclusive results, the general pattern remained similar. Productivity showed a gradual build-up at the start (often associated with unavailability of specific tools or materials at the time required, or lack of foreman instruction, or absence of key craftsmen). Steady progress in productivity continued unless interrupted externally, then followed by unexplained drag at the end, or often unfinished 10-15 % for a variety of reasons such as urgent start elsewhere, technical problems, or breakdown of tools.

Indeed, for every person experienced in site construction, it is evident that there are problems related to *starting a task*. After they have been solved, new problems *during the task* emerge. And finally, there are problems related to *completing the task*. However, these problems are assumed away in task planning, where a constant productivity is usually assumed (Fig. 5). This is reinforced by the habit of representing tasks as neat, well-defined rectangular boxes. However, if we consider productivity (or output), tasks cannot be considered as rectangular boxes – rather, the productivity increases slowly to its maximum, decreases through interruptions and typically there is a tail end to be completed later, often just before handover (Fig. 6).

In view of this, the simplified explanation[2] of Last Planner is as follows: *The Last Planner System endeavors to recreate the neat rectangular form of a task output, starting sharply,, reaching the sustainable and stable output level immediately, maintaining it to the end, and thus finishing the task as planned, without any tail end.* For so doing, Last Planner utilizes its seven features, the contributions of which can be allocated to the solution of these three problems (Fig. 7).

[2] Note that this explanation is parallel to the argument that Last Planner is primarily addressing the waste of *making-do* [7] but avoids the use of difficult operations management terminology.

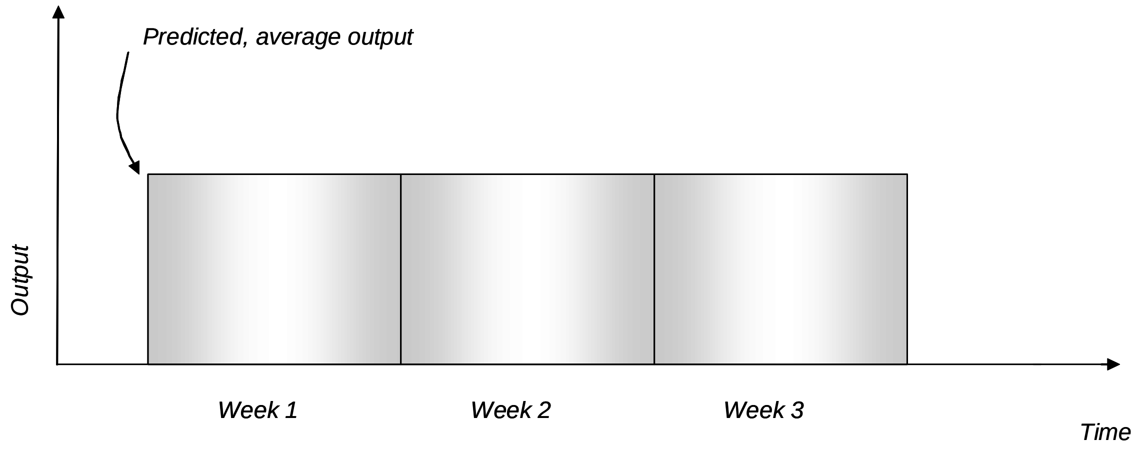

Figure 5.Task output as assumed.

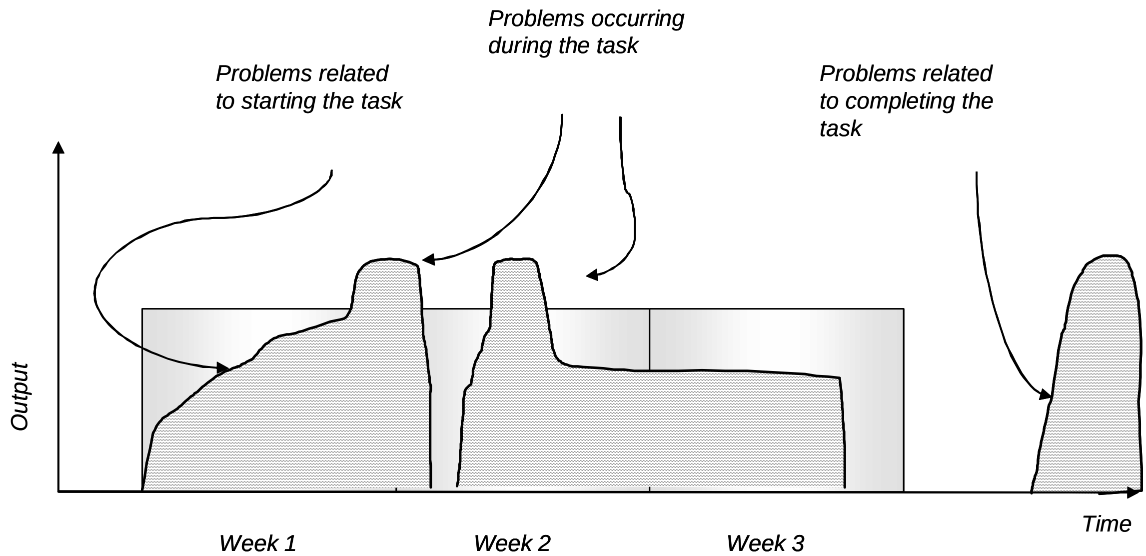

Figure 6. Task output in reality (illustrative example).

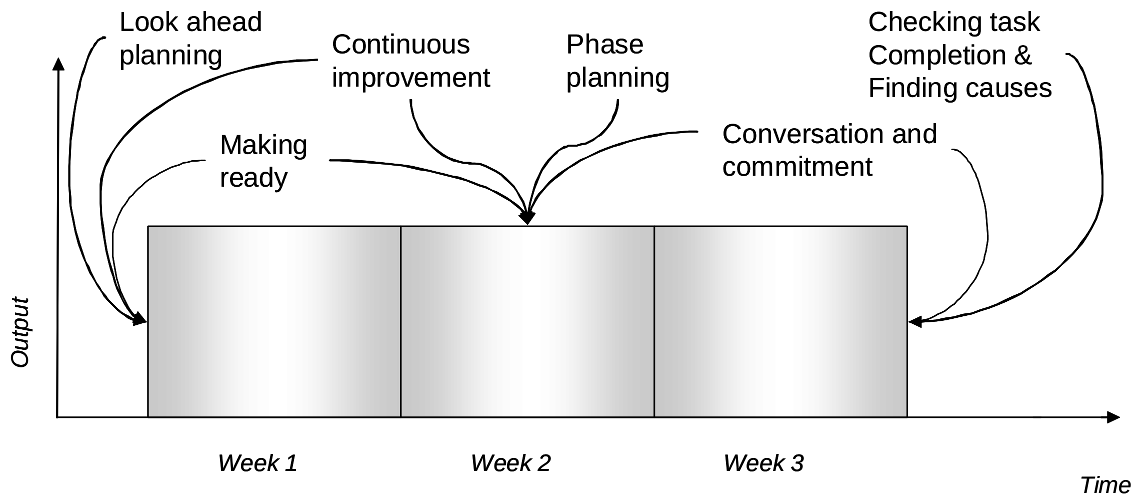

Figure. 7. Using the features of Last Planner for ensuring a sharp start, constant uninterrupted progress and planned completion of the task (only the primary mechanisms indicated).

The problems related to starting a task are addressed in three ways. In *lookahead planning*, there is a focused effort towards eliminating constraints for starting tasks: prerequisites are pulled (rather than pushed). Secondly, the *ready making* function ensures that only tasks with all prerequisites available are actually started. Thirdly, *continuous improvement* will for its part contribute to the reduction of starting problems on longer term.

Regarding problems during the task, there are three mechanisms. First, *phase planning*, carried out in collaboration between different teams and subcontractors, ensures that the best order of tasks is determined, and thus the risk of unforeseen interference between tasks is diminished. Second, *ready making* is focused on weekly tasks, and thus the prerequisites of longer tasks are checked weekly, rather than only at the start of the task. Third, all the weekly tasks are covered in the weekly planning (*conversation and commitment*), and thus in principle there should not be unplanned tasks emerging during the week, causing interruption or interference to planned tasks. However, in practice, there often is unplanned work to be carried out, but as plan reliability progressively increases along with use of the Last Planner, its amount will decrease.

When it comes to problems related to completing the task, first, all features mentioned above in relation to the two first problems help to avoid these completion problems. For example, a problem related to starting (say, shortage of materials) or a problem emerging during the task (say, necessity to move the gang temporarily to another work) may halt the task for the rest of the week. Second, task completion is specifically addressed by the planning conversation resulting in *commitment* to realize tasks as planned. Thirdly, *checking of task completion* as well as *finding reasons for non-completions* emphasize the need to realize and complete tasks as planned.

Next, the benefits of Last Planner can be explained. The elimination or at least alleviation of these three problems leads to direct benefits in terms of productivity, safety, quality and duration:

- Productivity. Each task can be sharply started, when all prerequisites are at hand. Interruptions and interferences are minimized. There are fewer tail ends, requiring a revisit by the gang.

- Safety. In comparison to the prior situation, a bigger share of tasks can be carried out as planned (including safety issues) and within regular conditions.

- Quality. A bigger share of tasks can be carried out as planned, in regular conditions, in one pass.

- Duration. Plan predictability increases along with the elimination and alleviation of the mentioned three problems. Thus, the time buffer between consecutive tasks can be shortened, with leads to a shorter total duration.

6. The Present Status and Prospects of Last Planner in Finland

At the moment, Last Planner seems to have firmly settled down in Finland. It is used by several individual construction managers, and there are pilot projects underway in two major contracting companies. There is training and facilitation available to companies through a Last Planner trainer certified by the Lean Construction Institute. There is a manual for Last Planner, published by the Confederation of Finnish Construction Industries.

However, it would be wrong to assume that the production planning paradigm has already changed in the country. The diffusion has been more bottom-up than in other countries – there has not yet been a locomotive company implementing Last Planner systematically and widely in its activities. Likewise, the curricula in universities and technical colleges tend to stress the conventional production planning mode, even if Last Planner has been point wise introduced.

One explanation to the inertia observed is that many key professionals seem to passionately subscribe to the conventional production control methodology. For them, the rejection of the master schedule as the primary tool for controlling a project is not something that could be accepted easily. Also, the temptation of automating the preparation and monitoring of the master schedule through IT tools has been irresistible to many.

7. Conclusions

The Finnish experiences on the introduction of Last Planner are to a great part similar to those gained in other countries, but to a certain degree there are novel emphases. There is similarity especially in the observation that Last Planner is a powerful method, which has already been demonstrated in pilot implementations and provides clear benefits (compare [4]). Other significant observations, some novel, others adding to prior evidence, emerging in the framework of Finnish experiences include the following:

- *Theory-based approach*. A simplified way of explaining and justifying the Last Planner method for construction professionals was developed. The training time could be reduced, and justification of the method to managers was made easier. Also, the introduction of the Last Planner into the national educational and training system seems to require that a detailed theoretical justification, especially in comparison to the traditional way of production control, can be presented.

- *Incremental introduction*. The method was structured into seven parts, and a logical order for their progressive introduction on site was developed. A rationale for each part, connected to the overall explanation of the method, was developed.

- *Need-based facilitation*. A method of facilitation emerged where the intensity of facilitation progressively decreases according to the advances and learning made on site.

- *User acceptability*. The user acceptability of the method emerged as a critical feature. The users of the method must themselves realize the superiority of the new method, if a successful implementation is targeted.

- *Contextual tailoring*. The method has been tailored in operational details to match the existing production control methodology of the company.

Acknowledgements

The authors want to thank the Confederation of Finnish Construction Industries, the Technology Development Agency (TEKES), the Finnish Work Environment Fund and VTT Technical Research Centre of Finland as well as the involved contracting companies for their funding to the Last Planner projects.

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Case Studies of Using Flowline for Production Planning and Control

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Abstract

Flowline, or Line-of-Balance, has recently gained attention in Lean Construction literature because of its capacity for facilitating control of production flow and planning of continuous work. In the broader technical literature, previous work has concentrated on the analytic properties of flowline, such as learning curves, and is generally silent on how the method should be used to improve productivity. This is because internationally the technique has received relatively little application. However, in Finland, flowline has been used as the principal scheduling method since 1980s.

This paper takes a practical approach and describes the use of flowline based planning and control in two real case projects. One of the projects is a large residential construction project in Sydney, Australia. The other project is a Finnish retail park construction project. These pilot projects were done at the same time and the projects were able to learn from the experiences of the other. The cases highlight the differences between the Finnish way of planning a schedule with buffers between activities with synchronized production rates and the Australian way of driving a schedule with a tightly constrained CPM schedule.

A methodology using flowline as a visual planning tool but using familiar CPM logic as the underlying engine was appropriate in the Australian case. In this methodology the objective is to improve site control by including information about location and to be able to plan continuous work for subcontractors and to visualize the effects of planning decisions. The result is much clearer communication to the trade contractors about the timing and location of their work, improved control systems and better work flow. The Finnish project team was already familiar with the basic use of flowline so the more advanced risk management based approach was used. The risk management based approach includes using quantities estimated by location as the starting point and optimizes the crews so that the risk of schedule disturbances is minimized. The planning happens on two levels: the master schedule has less detail and the task plans are detailed plans of individual tasks which are done by persons responsible for the work when all the necessary information about implementation is available. The results from the Finnish case include a methodology for effectively controlling production flow and how to include the subcontractors in the process.

Comparison of the two different strategies reveals important knowledge about the role of custom in scheduling, and reveals potential barriers to adopting innovative approaches.

Keywords: Flowline, line of balance, scheduling, implementation

1. Introduction

1.1 Flowline and its Applications

There are two main methodologies for scheduling work: activity-based scheduling and location-based scheduling. These two methodologies in turn have many methods and techniques, often designed to achieve the same purposes in different ways [1].

The dominant scheduling technique is activity-based scheduling and it was first developed in the 1950s [2]. The technique relies on the construction of a logical network of activities in three visual forms; activity on the arrow, activity on the node and logical dependency constraints [3], with four levels of complexity; deterministic (for example: CPM), probabilistic (for example PERT) generalized activity networks [3] and arguably the more recent critical-chain method [4].

A familiar to many, but relatively little used, alternative scheduling technique is that of location-based scheduling, more frequently known as repetitive scheduling. Originally developed by the Good Year Company in the 1940s and expanded by the US Navy in the 1950s [5], the suite of techniques has found strong support in continuous production systems (more typical in engineering construction) but only limited support in commercial construction. Finland is a notable exception to this, as the technique is the dominant method in the Finnish construction industry. Harris & Ioannou [6] summarize the various names (and sources) given to the variations in the method, including 'Line-of-balance', 'Construction planning technique', 'Vertical Production Method', 'Time-Location Matrix model', 'Time Space Scheduling method', 'Disturbance scheduling' and 'Horizontal and vertical logic scheduling for multistory projects'. Interestingly they do not identify perhaps the most evocative term, that of 'Flow-Line' [7]. Harris & Ioannou [6] also identify the terms used in engineering construction such as highways, pipelines and tunnels, as 'Time versus distance diagrams' (TD charts), 'Linear balance charts', 'Velocity diagrams' and 'Linear scheduling'. [8] also identify 'Horizontal and vertical scheduling', and 'Multiple repetitive construction process'–but aims these at the specific case of vertical replication repeated in multiple buildings.

All these methods involve repetitive activities and for this Harris and Ioannou suggest a new generic term 'Repetitive scheduling method (RSM)'. However the methods also strongly suggest location or place, and thus the use of the term 'Location-based scheduling' proposed by Kenley [1].

1.2 Background

Activity-based scheduling dominates most of the world's construction industries. This is certainly the case in the Australian industrial context. Little needs to be said to describe the common methods for planning projects, as they will be familiar to most. Essentially they are driven by software such as Primavera (the most commonly used package), Microsoft Project and equivalent CPM tools.

The education system in Australia generated students with a deep understanding of the underlying mechanisms of CPM planning until the mid 1980s. These students were also generally exposed to alternative manual methods such as Flowline [7]. Students of Walter Mohr [7] were more exposed than many. The advent of powerful software on micro-computers subsequently lead to a reliance on packages for the teaching of planning. It is fair to say that nowadays, construction management courses teach the use of software, paying only a cursory interest in the underlying principles and methods. A consequence of this is a lowering of planning skills, except in the use of software, and a reliance on common approaches. Accordingly, it would be extremely rare to see application of location-based scheduling in Australia, indeed few people would have the skills to understand the method.

Furthermore, location-based scheduling is best driven by location-based measurement (BOQ). The standard method of measurement in the Australian industry does not allow for location-based measurement. The industry has also substantially moved away from measurement of commercial building projects, particularly those procured using Design and Construct methods, and many commercial contractors simply do not have adequate measurements to support location-based techniques properly.

In contrast, location-based planning methods have been used widely in Finnish construction since the 1980s. The methods were brought to Finland and adapted to commercial construction by professors Kankainen and Kiiras from Helsinki University of Technology [9], [10]. In research tests it was established that the use of modified flowline planning increased productivity and decreased waiting hours for own workers and for subcontractors [11].

Finland suffered from severe economic recession during 1990s during which many construction companies went bankrupt and the value of real estate plummeted. During the recession, training of construction management professionals and construction engineers practically stopped because jobs were not available. This has resulted in a lack of skilled engineers in the field when the economy began to recover. During the recession the flowline scheduling skills were forgotten and the industry reverted back to using gantt charts which could be easily drawn by using computers. The only available flowline software was a drawing tool and wasn't suitable for complex planning.

New research efforts to improve the scheduling skills of the industry were started at the end of 1990s by professor Kankainen's research group. The results included tools such as task planning [12], project control charts, checklists to assess schedule's feasibility [11] and new contracts to support location-based control. The research results were used in a software development project to design a new software able to be used as a planning and control tool. The features of the software DynaProject™ have been described [13].

Because of popularity of the location-based graphical methods, Finnish construction companies had never really adopted CPM –based methods. Activities which are linked by precedence logic are rare in Finnish schedules. The schedule is used as a visual planning tool and the planners check for logic errors by examining lines which cross in the flowline diagram.

It is clear, therefore, that a comparison between the Australian industry and the Finnish industry, the methods and practices of planning, would cast valuable light on the culture of planning in both countries. In this paper, the experience of planning using location-based scheduling techniques on a specific project case study from each country is discussed; allowing comparisons to be made and conclusions drawn about the differences in the culture of planning in each country.

2. Case 1: Residential Construction Project in Sydney

2.1 Description of the Project

Victoria Park stage 302 is a residential complex in inner Sydney. It comprises four residential towers of varying heights, joined through a common podium. The largest tower was fifteen floors, the next nine, then eight and four. There were approximately 300 apartments in total. The schedule was from May 2004 to June 2005.

2.2 Available Starting Data

Walter Construction Group was totally new to flowline based production control systems. All their systems revolved around CPM and Primavera. As this was a trial to develop more efficient management systems, both CPM schedules and flowline schedules were developed.

There was no quantity take-off done corresponding to the physical locations of the building. Nor was there any available database of production rates. This is common within the Australian industry, where sub-contract packages are generally allocated a number of days of work for each task, in precedence logic, and no attempt is made to ensure continuity of work flow.

2.3 Scheduling Process

Because of the poor starting data, it was difficult to schedule the project using location-based methods. It was necessary to take the CPM schedule and artificially apply it to a location-based methodology. This presented the first significant barrier to implementation: the automatic systems designed into the software could not be used and the inability to use quantities and productivity data exposed the shortcomings of CPM only systems which are not sensitive to designed productivity changes.

The CPM schedule was never fully completed due to the complexity and scale of the projects. Therefore, the CPM schedule calculated a typical floor in detail, then replicated this for each floor. This is understandable, as with 300 apartments and with approximately 50 activities to schedule, it would be necessary to schedule around 15,000 activities. In contrast, the location-based methodology required only 50 activities, with the approximation of quantity in each of 300 locations. A simple trick was employed to achieve this: The unit of quantity measured was a standard shift, with the number of days of work being the actual measurement. This rough approximation allowed reproduction of the CPM schedule, but exposed the problem of manipulating the productivity to improve the schedule (and indeed the problem of a culture of fixed durations existent within the industry – a topic for future research).

One important lesson is that this sort of power leads to extremely rich and complex schedules. The loss of dominance of the critical path, replaced by dominance of work-flow, results in project models with large quantities of information – all very powerful for managing the project. To illustrate the complexity, a small section of the finishes schedule for one part of one building is displayed in figure 1.

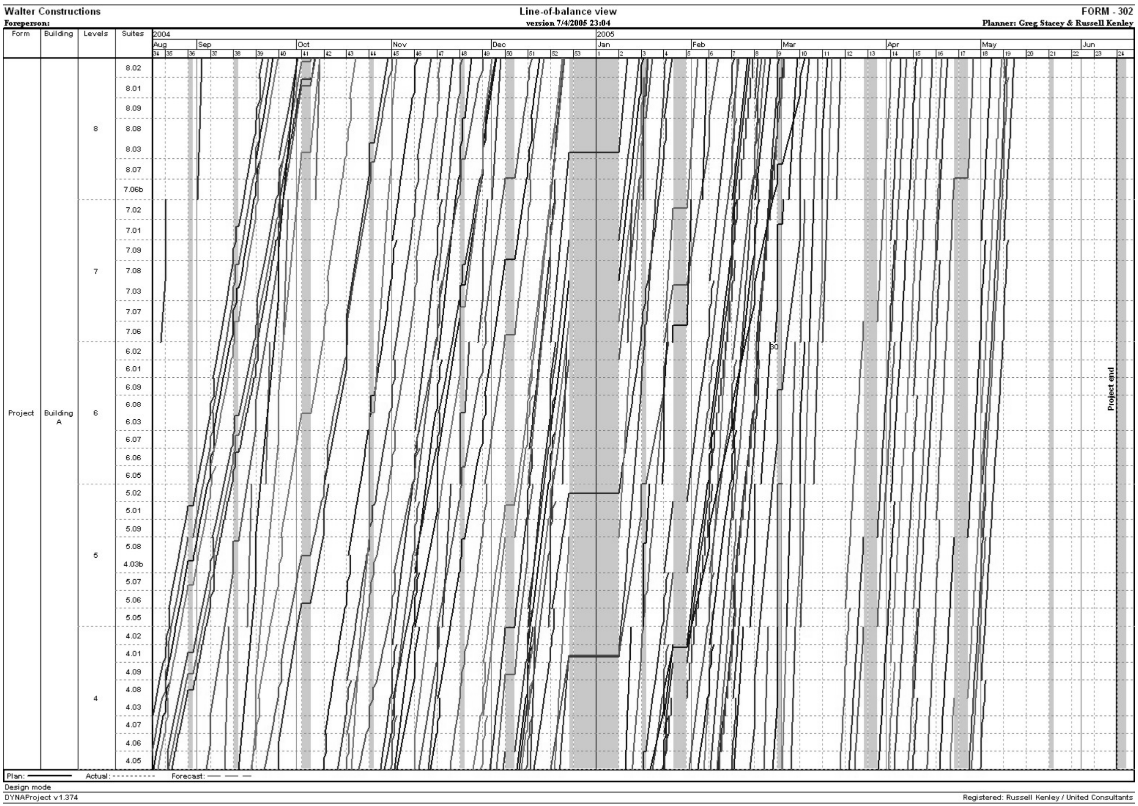

Figure 1: Section of finishes schedule for Victoria Park.

The initial schedule resulted in a duration far in excess of the required duration. In order to simulate alteration of work-crew productivity (the normal method), activities were resourced with work-crews with $1/10^{th}$ productivity – and a base multiple of 10 units. Thus 20 units would double productivity and 5 would halve the productivity.

After manipulation, a schedule was developed which conformed to the duration requirements, but which ensured that each work-crew was able to work continuously, without interruption, from start to end of the project. In the words of one site manager on a later project, "Do you mean to say that we can not only finish on time, but also have continuous work?"

In contrast to the finnish methods described below, the contractor wanted to continue their use of scheduling in extreme detail. This may be termed micro-management [1] and scheduling to such detail was considered most unusual by our Finnish colleagues. Their risk management approach results in less detail and simpler schedules. The detailed approach dictated by a CPM culture results in much more detailed schedules, more complex models but powerful management tools when used correctly.

2.4 Control Process

The project schedule was completed prior to commencement of the finishes work on-site. The planned control process was to work with the sub-contractors to ensure their productivity rates matched with the plan. Once this was done, each work-crew would be able to work continuously, systematically and without interruption – this greatly enhancing their financial performance and that of the project.

The reality was very different. A competing process was being employed on the project in the design stage and unfortunately spilled over into the site-work phase. This process, called *Project Blue* [14] involved intensive focus on team work and integration – very valuable aims. However, the methodology for site work was strictly CPM – and followed the original CPM planning method. A typical floor was worked out according to the original plan and trades were told to "pass work on" to following trades. Unfortunately, this method fails due to the conflict between a typical floor schedule and the need to flow resources through multiple floors and buildings. The result was largely chaos, work out of sequence and a loss of control. Such performance was largely accepted however, because this is unfortunately normal practice on any Australian project.

The result of this conflict is that the location-based control system was never implemented. The company subsequently reviewed the project and determined that on future projects the method would be implemented rigorously and not be sabotaged. A special project team was initiated to follow this through.

Unfortunately, it must be reported that, due to the failure of the German parent company, Walter Construction Group failed in February 2005 and this implementation project has now stopped.

2.5 Lessons

This project highlighted that CPM scheduling done in the traditional way presents major problems for site management which are generally managed by the site staff though working out of sequence, discontinuous work and work interruptions.

In contrast, a location-based approach such as flowline has the capacity to deliver more efficient site work. However, successful implementation requires significant cultural change before it can be successful. Even with senior management support, the project management team must support the innovation.

3. Case 2: Business Park Project in Helsinki

3.1 Description of the Project

Opus business park is a 14 500 m2 office building in eastern Helsinki. It is composed of two sections, which can be built independently of each other and of parking hall below the main building. Both sections have six floors. The total schedule is from August 2004 to December 2005.

3.2 Available Starting Data

NCC Construction has devoted a lot of resources to implement flowline based production control systems [15]. The quantity take-off is done corresponding to the physical locations of the building. In this example, all the quantities had been distributed to sections and floors so that they could be directly utilized in flowline planning. Labour consumption information has also been standardized within the company allowing for a very fast planning of first drafts of the schedule. Also the building services quantities are estimated based on project characteristics and size. The productivity and quantity databases include information about subcontracted work. The main principle is that subcontracted work should be planned as if it were done with own resources because otherwise effective control is impossible.

3.3 Scheduling Process

Because of good starting data, it was possible to create many different alternative schedules in a short period of time. Two main alternatives were examined:

- Completely continuous schedule
- Work continuous in sections but a break between two sections

Completely continuous schedule would have had the same end date as partially continuous schedule but both sections would have been finished at approximately the same time. Partially continuous schedule achieved much of the same benefit but enabled the first section to be finished earlier thus reducing the risk of exceeding the total duration. The project team decided to implement the partially continuous alternative and take the break between sections into account in contracts with subcontractors.

It was not possible to change the sequence of sections because the parking hall had to be handed over before the second section could be started. This was because the second section was used as a temporary parking lot for customers of the neighboring supermarket. If the second section could have been built first, the project duration would have decreased by one month.

In the final schedule the production rates have been synchronized and a buffer has been planned between the most important activities. All task durations are based on quantities, resources and productivity data from earlier projects or from Finnish productivity database, which has been created as a joint effort of the industry [16]. The final master schedule is shown in figure 2 (only the space-critical activities shown).

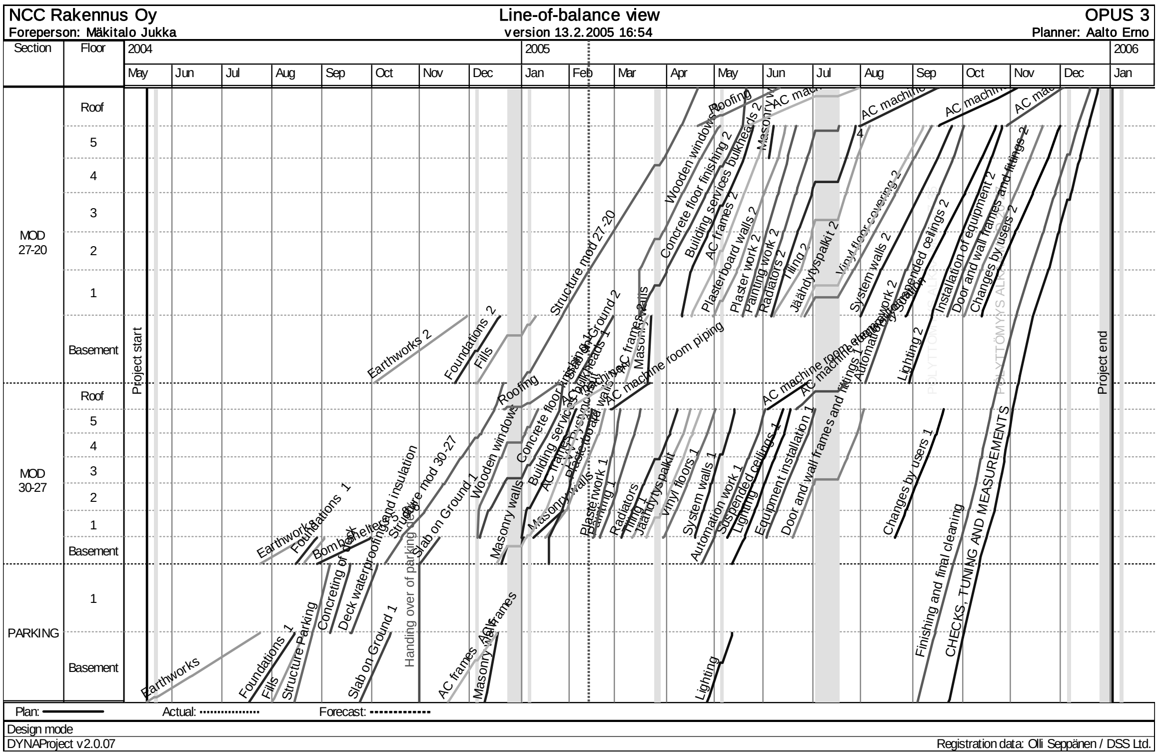

Figure 2: Master schedule of OPUS project – only the space-critical activities are shown

3.4 Weekly Control Process

The weekly control process was based on task planning method [17]. The schedule of upcoming master schedule tasks was exploded into more accurate level and the quantities were updated. This process started in the beginning of the project so by planning just one task accurately each week it was possible to always be well ahead of production. While the master schedule looks at production flow at "macro" level, the task schedules schedule continuous work for each worker and assure that the same worker won't be in two locations at the same time. Task schedules are constrained by the master schedule so that task schedule must finish all subactivities in a location before the next master schedule task begins in that location. Task schedules are updated weekly to always correspond with the current situation but the master schedule is never updated. This is because updating the master schedule has been shown to fool the site management into false sense of safety. In reality updating the schedule shifts the problems towards the end of project and leads to hurry in the end of project [11].

Every week on Tuesday, the actuals from the last week were compared with the weekly assignments derived from all of the task schedules. The data was collected from site by using the control chart, a matrix of locations and tasks which shows with color codes the status of each location [13]. The reliability of task plans was measured by calculating the percentage of planned assignments completed (PPC) during the week. This measure is the same as in the Last Planner™ system of production control (e.g. [18]) but the assignments are the result of flowline-based task planning process.

All existing task schedules were updated next to take changed circumstances and actual production into account. Actual production rates were used in task schedule updates to make schedules more accurate and to show increased resource needs. The master schedule sets the boundaries for planning so the problems couldn't be pushed farther than the end of master schedule task in a location. All the updating was done using best possible information. The aim was to make best possible forecasts for the rest of the task while preserving continuous production for as many workers as possible. Most effort was expended on updating the next week's plan because the next week's task schedules were commitments by the planners.

If there was sufficient information on a master schedule task which was about to begin in the next few weeks, new task schedule was planned. The first draft of the task schedule used accurate quantities taken from current drawings and estimated production rates. It was planned by the site engineer. Before beginning of production, the task schedule went through multiple rounds of comments by the subcontractor, the superintendent and procurement people.

After updating the task schedules the status of master schedule was evaluated based on computer-calculated forecasts. [19] If the delay of a task endangered the continuous flow of another task, control actions were planned by updating the task schedules to minimize the risk of interference. Actual situation and resource availability of the subcontractor as well as the cost effects of acceleration were evaluated to arrive at the best solution. If interference couldn't be avoided, task planning was used to estimate the optimal time to continue production for the disturbed trade.

The resulting set of task schedules were up-to-date, took into account the availability of resources and were based on actual circumstances. From these task schedules the production objectives for the next week were established. These objectives were communicated to the subcontractors and superintendents. Their success was evaluated in the next Tuesday's schedule update by calculating the PPC.

This weekly control process took two to four hours time from the project engineer and one of the authors (OS). In addition, the project engineer used time in communicating the plan, assessing the circumstances and getting the actual data from site.

3.5 Results

The project was still on way during the writing of this paper. The structure of the first section and the parking hall were finished and the interior works of the first section were on way. In spite of many deviations from the plan, the project was overall on schedule. Main problems included earthworks and structure. Structure had too tight a schedule in the master schedule, a fact taken into account in risk analysis. Because of the buffers between structure and interior work, the delay of structure didn’t have an impact on the interior works and their flow wasn’t disturbed. However, the structure of the second section started late because it was using the same tower crane. Control actions are needed in the immediate future, or there will be interference in the second section. Figure 3 shows actuals (dotted lines) and forecasts (dashed lines) on top of the original schedule (solid lines). Master schedule hasn’t been updated and can still be used to control production. The results indicate that the master schedule was on sufficiently rough level of detail that it could accurately forecast how the project would be carried out.

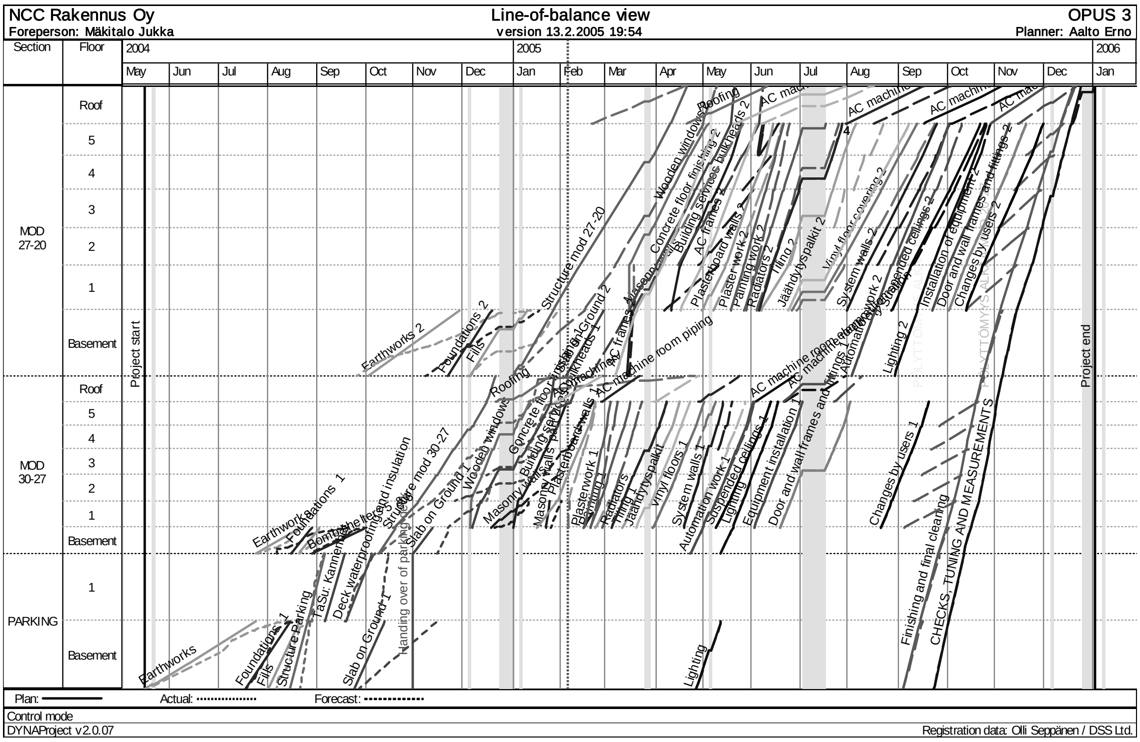

Figure 3: Master schedule of the Opus project planned lines (solid), actuals (dotted lines) and forecasts (dashed lines)

Systematic weekly control process improved the project team’s feeling of control. Measuring the percentage of weekly assignments completed (PPC) was found to motivate the team to take planning more seriously and to strive for best possible results. This showed in an increase of the PPC from 50 % level to near 80 % level during the initial stages of the project. Improvement in PPC correlated with the catch up of the schedule.

Combining task planning with master schedule based schedule forecasts worked well because if the site set too relaxed weekly targets, the master schedule forecasts alarmed that there will be problems in the future. If the site set too tight, unrealistic objectives, the PPC value plummeted. Catch up can be planned to be incremental by updating the task plans. By combining the systems, the site can set realistic objectives, commit to them and maintain control of the overall schedule.

4. Discussion

There are very significant cultural differences between the methods, despite the fact that the same software tool was being employed. Indeed, it was realised that neither group could really understand the schedules generated by the other.

The Australian planners, while they liked the idea of the risk management schedules and the rapid construction of schedules from quantities and templates, could not accept their validity in their context and insisted on their detailed CPM-like, micromanaged, flowline schedules. They didn't understand the concept of buffers, preferring instead a fixed lag (delay) between activities in the network.

The Finnish planners, in contrast, had never seen such large and complex models, and were fascinated by the complexity, but equally could not justify the approach, fearing that such precision and detail without buffers in time or location, would lead to problems in implementation.

This illustrates that the risk management approach and the CPM approach provide two completely different planning systems. Improving our understanding these differences, now identified, will be an important research project for the future.

5. Conclusion

Flowline, as a technique, and DYNAProject™ as a software tool, have demonstrated their capacity to be used in completely different ways according to the underlying planning culture. This project demonstrated that flowline can provide a powerful planning and control tool for projects, with two completely different methodologies available.

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Procurement Strategies for Dynamic Control of Construction Projects and Supply Chain

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Abstract

The efficiency and the effectiveness of construction processes have previously often been discussed and criticised. Obviously the final goal of parties within a construction project is the completion of the project. However it is not necessarily a goal in itself to organise the process as fast and efficient as possible. Most practitioners in construction consider that ‘quality versus time versus cost’ is a zero sum game, and hence, whenever there is a choice among the three, usually quality is often the first to be sacrificed. The core of this problem lies within the classical project delivery methods not aiming to bring together the different interests of the value demanding and the value supplying parties, and not shielding the process against negative effects from outside the project. Most project delivery methods are set up in such a way that an increase of profit for one party often means a loss of profit for the other party.

The concept of dynamic control aims at bringing together the different interests of the value demanding and value supplying parties within the building process. It aims at the improvement of added value for demanding parties as well as profit levels of supplying parties, and thus the total benefit of built facilities, i.e. the sum of added value for clients and profits for suppliers. However contracting practices and procurement strategies need to support this positive mechanism and build-in positive incentives for parties to join in a collective effort to search for the optimal solution and overall benefit.

In this paper the concept of dynamic control is combined with alliance contracting principles and delivery method. It is argued that alliance contracting is a beneficial procurement strategy to achieve the goals of dynamic control, i.e. achievement of joint benefit through a collective process of progressive development of value and costs, and thus added value for demanding parties and profit for supplying parties. This results in a basic alliance framework for dynamic control and project delivery, illustrated with practical solutions and methods.

Keywords: Construction, dynamic control, incentives, procurement strategies, project alliance, supply chain.

1. Introduction

The efficiency and the effectiveness of construction processes have previously often been discussed and criticised. The characteristics of construction, such as fragmented demand and supply chains, the complexity of projects and long lead times are basic causes, often leading to cost and time overruns, delivery of less value than agreed, and dissatisfied clients and users [15].

The concept of dynamic control aims at bringing together the different interests of the value demanding and value supplying parties within the building process. It aims at the improvement of added value for demanding parties as well as profit levels of supplying parties, and thus the total benefit of built facilities, i.e. the sum of added value for clients and profits for suppliers. However contracting practices and procurement strategies need to support this positive mechanism and build-in positive incentives for parties to join in a collective effort to search for the optimal solution and overall benefit.

In this paper the concept of dynamic control [9, 10, 11, 12, 13, 14, 15] is combined with alliance contracting principles and delivery method. It is argued that alliance contracting is a beneficial procurement strategy to achieve the goals of dynamic control, i.e. achievement of joint benefit through a collective process of progressive development of value and costs, and thus added value for demanding parties and profit for supplying parties. This results in a basic alliance framework for dynamic control and project delivery, illustrated with practical solutions and methods. The illustrated solutions are derived from three cases that were examined in three MSc. theses delivered at Delft University of Technology [7, 20, 26].

2. Value Engineering and Value Management

Crum [8] defined value engineering as a disciplined procedure directed towards the achievement of necessary functions for minimum cost without detriment to quality, reliability, performance and delivery. Heller [17] defined it as a shift from finding the lowest cost way to produce the product finding the lowest cost way to perform the desired value.

Kelly and Male [19] observed value engineering as a subset of value management. Value management can be structured across the life cycle in three phases: value planning (definition, development), value engineering (design implementation) and value review (operation, end of asset) [23]. The process is integrated through systemic planning and feedback across the entire process. Through a value management and teamwork approach value criteria and benefits of all stakeholders must be assured in a lifecycle perspective. It is argued that the cost savings potential of value management decreases along the life cycle and must therefore be applied from the early phases of construction projects (i.e. design) [22].

Project delivery methods should therefore give room to value management in the earliest stages of the project. Not only by integrating the value demanding and supplying parties in the early phases of a project, but also by making both parties aim for the same goals in the project by raising the difference in interest. Only then will the different parties within a project work together on the same goals. This is the creation of as much as possible added value, within the set boundaries of cost and time.

3. Interests and Goals in Construction

The value demanding parties have different interests then the value supplying parties within a project. The value demanding parties' interest is to gain as much as possible added value (benefit) for the lowest price possible. The value supplying parties' interests on the other hand is to gain as much as possible profit (difference between price and costs) from the project (see figure 1).

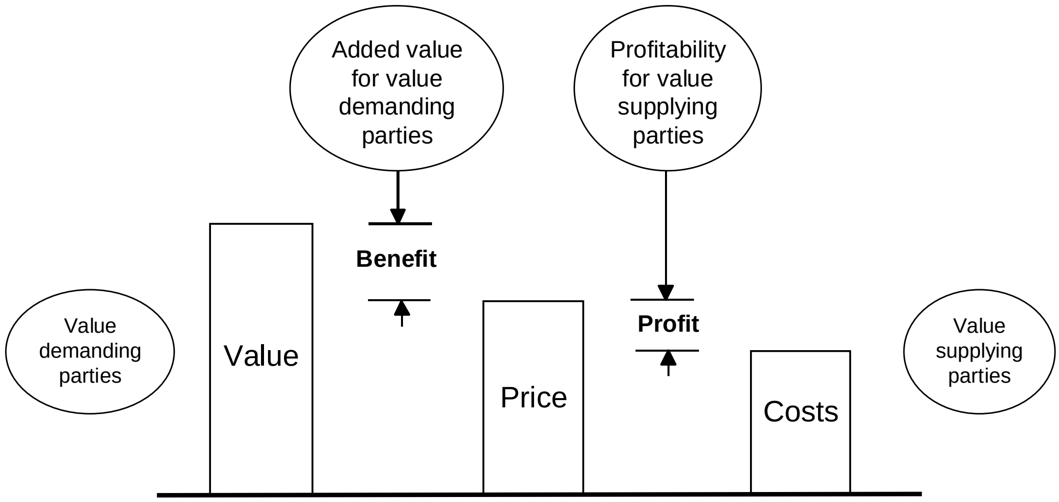

Figure 1: Goals of value demanding and supplying parties in construction projects [15].

The classical project delivery methods do not address this problem. Thus keeping the different parties having different interests within a project.

The interests of both parties have to be aligned to be able to form an integrated team that aims for the same goals. This means that the amount of profit of the value supplying parties has to depend on created added value that is delivered to the value demanding parties.

De Ridder and Vrijhoef [15] have proposed this idea also in their Value-Price-Cost leverage model for the integrated control of value, price and costs of construction projects. The ultimate objective of this idea is to optimize the total benefit of the built facilities through the lifecycle. This paper looks at how this idea is integrated into the project alliance delivery method.

4. Dynamic Control

Previously De Ridder [9, 10, 11, 12] has introduced the concept of dynamic control. The concept is based on the paradigm shift from a discrete process of fixed prices on fixed contract moments between the different phases in the life cycle (static control), towards a continuous process of establishing and monitoring the VPC balance through the life cycle, and acting in case of changing demands or circumstances (dynamic control). In short, dynamic control aims at the improvement of added value as well as profit levels, and thus the total benefit of built facilities, i.e. the sum of added value for clients and profits for suppliers

In order to maximize the benefit, two basic strategies can be distinguished (Figure 2). The first strategy is to add extra value against a small amount of extra costs. The second strategy is to accept a bit less value against substantial less cost. In terms of quality, Bogenstätter [6] approaches these strategies by proposing 'more quality for the same money' and 'same quality for less money'.

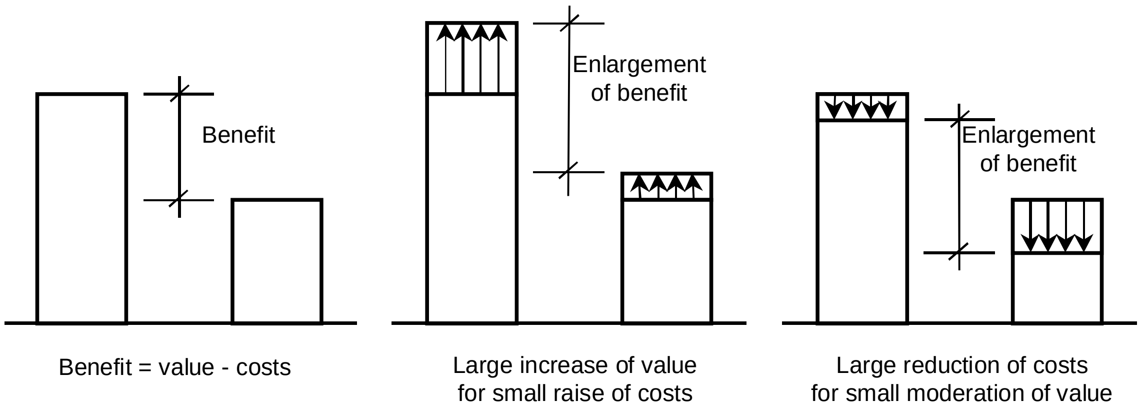

Figure 2: Two basic strategies for the maximizing benefit [15].

The coupling between value, price and costs is essential for dynamic control. The coupling is two directional. This means that value, price and costs must be balanced in the most beneficial way for the all involved parties, thus for value demanding parties as well as value supplying parties.

The two respective couplings between value, price and costs are represented by the brief (value-price) and the working concept (costs-price). The two couplings are the basis of the dynamic control concept. The brief (program) balances the desired value and the price the demanding parties are willing to pay for the built facility. This balancing is a continuous process, and takes place in all stages of design and construction, however on an increasing concrete level. The concept represents the coupling between price and costs. In the design, the supplying parties work out a concept that meets a maximum cost level based on the demanded value and the desired price. Balancing price and costs is also a continuous process, in which additional costs, risks and uncertainties influence the balance between price and costs, and determining the ultimate price, that is often higher than expected.

Demanding parties and supplying parties each have a different focus on the balance they want to optimise. The interests are basically opposite. Demanding parties want to maximize the difference between value and price. Supplying parties want to maximize the difference between costs and price. As a consequence, the interaction between demanding and supplying parties should be focused on integrated balance of the value, price and costs, and maximizing the total benefit through the integrated development of the brief (design program) and the concept. The price is the "lever". Due to the dynamics of the process, this calls for a convergent process of continuous price forming, ultimately leading to a realistic price level in between the emerging desired value and an optimal cost level.

5. Project Alliance: An Applied Dynamic Control Method

5.1 Basic Concept

The concept of dynamic control has been applied in several project alliance projects [20]. It is done by the coupling of the term value of the value demanding parties with the possible profit of the value supplying parties. This is done is such a way that when value rises, the possible profit rises and when the value declines, the profit declines (see table 1).

Table 1: The coupling of the delivered value with the profit of the value supplying parties

Delivered Value (performance)	**Profit**
Good	Good
Normal	Normal
Bad	Bad

By the coupling, the value supplying parties shift from a price-cost (profit) mindset to a value-profit-cost mindset, because the final profit is directly dependent of the delivered value.

In a project alliance the partners bear a portion of the total risk, profit and losses. This way the partners are stimulated to collaborate in order to achieve maximum profit in relation to the delivered value. This contributes to the philosophy of partnering, which says that performance in terms of cost, time, quality, buildability, fitness for purpose and whole range of other criteria, can be dramatically improved if participants adopt more collaborative ways of working [2, 3, 4].

5.2 Condition One: Define Value

The first condition in being able to couple the delivered value with the final profit is by defining the term value. The term value will be different for every value demanding party. Globally the term value for the value demanding parties can be defined as the balance between time, price and quality [24].

5.3 Step Two: Setup a Benchmark And Set Incentives

The following step is to define the minimum quality level (process and/or product), the maximum price level and maximum time the project may take and setup a benchmark to measure these levels. Through the benchmarks the value is quantifiable, thus the profit can be made dependent from the measured levels. In a project alliance this is done through the so-called Risk/Reward schedule. The Risk/Reward schedule puts incentives on the measured levels of quality, price and time (for example see figure 3).

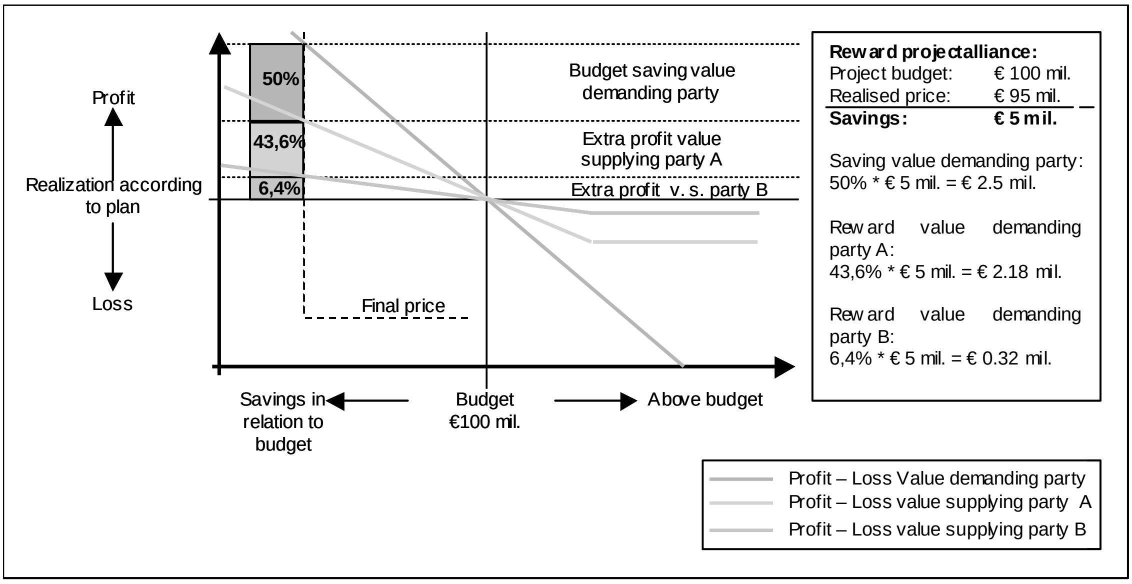

Figure 3: Example of incentive put on the realised price of a project (Risk/Reward-price) [7]

The Risk/Reward schedule (the three incentive schemes placed on time, cost and quality) should be balanced in such a way that the profit of the value supplying parties starts hitting zero as soon as the expectable minimum balance between quality, cost en time is in sight. The following example (figure 4) shows a project in which the quality level of the project is leading. When the quality of the project is low, even when the project is delivered on time and far under the budget, there will be no profit. This way the quality level is secured. There will only be a profit when the quality that is delivered is on the minimum adaptable level and the project is on time and within budget.

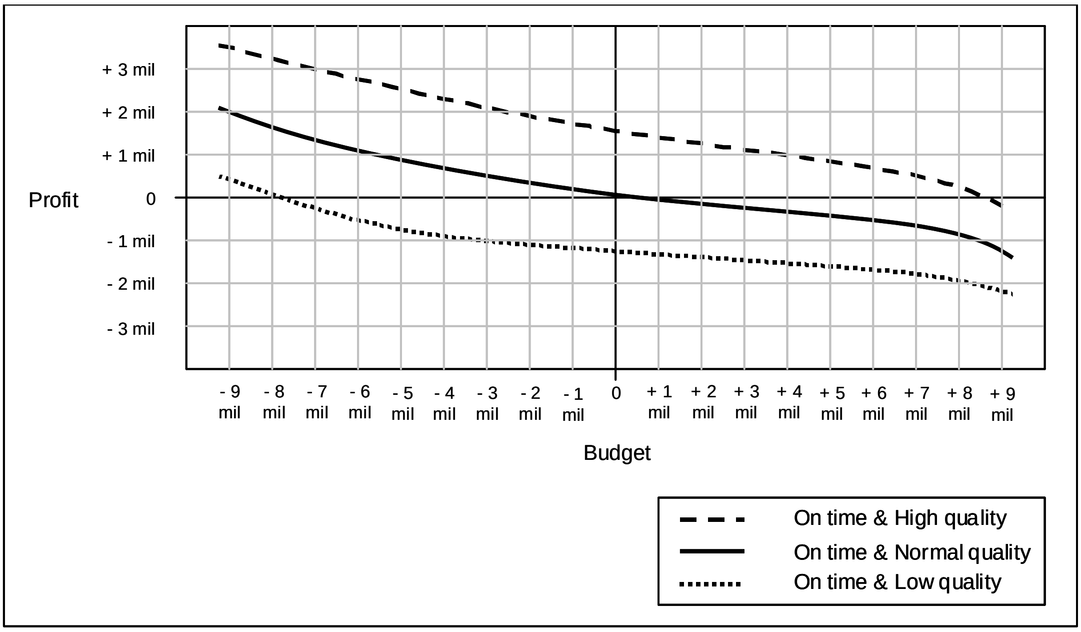

Figure 4:Example of profit coupled with the balance of quality, price and time, where the quality is leading [20]

There are however other aspects that need reckoning. In order to develop collaboration between the partners, only relying on incentives is too simplistic. Open communications, supporting policies, systems and practices are needed to stimulate and maintain collaboration [5,20,26].

5.4 Step Three: Open up the Building Process for Dialogue

The third condition is to open up the building process. Where normally the value demanding parties define the wanted value before starting the dialogue with the value supplying parties, it is now necessary to open up this phase to the value supplying parties. This is done because the value demanding parties are not yet certain about the product that has to be delivered [25]. This can be done for instance by putting the development phase after the selection phase of the project (see figure 5). This way possible optimisations and value enhancing ideas from the supplying parties can be integrated into the design, the phase where the cost for changes are low and the possible influence is high [22]. This means that the method of selection cannot be based on the evaluation of the bid or lowest price. It means the selection should be based on the qualities of the value supplying parties and their possible input into the project.

A direct consequence of the selection based on the qualities of the value supplying party is that the project has to be shielded for the selection of the wrong value supplying party. Selection based on the quality of a party can result into the selection of the wrong party, because this selection methodology is much less developed to date, than the lowest price criteria. The following steps should be incorporated [20] (see figure 5).

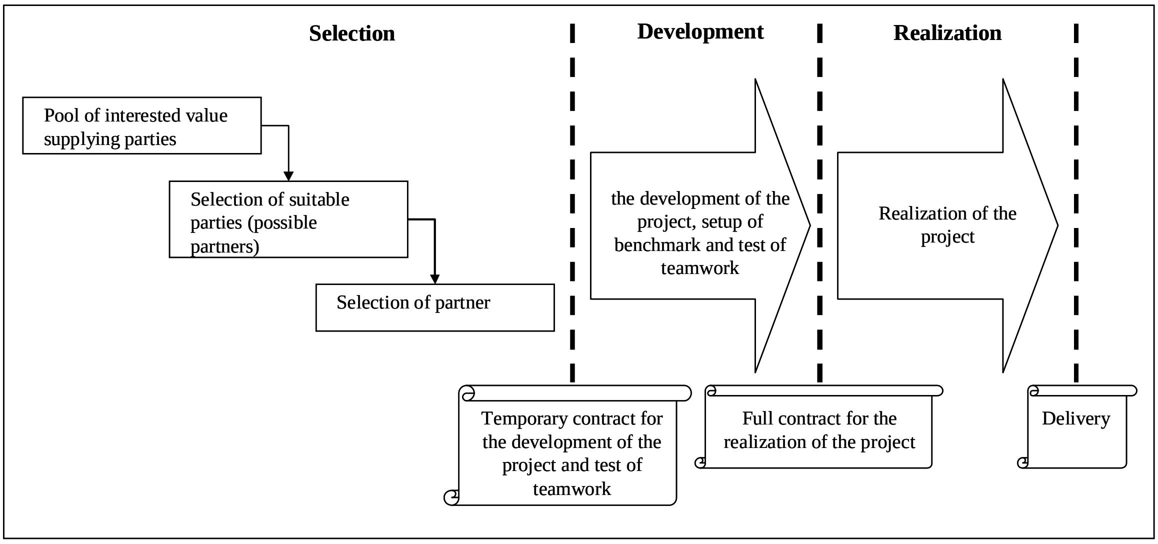

Figure 5: Steps in the tendering process of a project alliance

Figure 5 shows the tendering process for a project alliance. In this process the development phase has been placed behind the selection process. As a result the value supplying parties (including the contractor) will be contracted before the full scope of the project is visible. This is the reason why a temporary contract is installed. Under this contract the partners (including the value demanding parties) develop the project and the benchmarks (for the Risk/Reward-scheme). If the development phase is satisfying for the value demanding parties, the temporary contract can be converted into a full contract for the realization of the project.

6. Demand and Supply Chain Integration In One Organisation

A project alliance can be seen as a delivery method that integrates the demand and supply chain. Client, contractor, architect, consultant and even subcontractor can form a joint venture for the duration of the project [20]. For the duration of the project, the members form a temporary organisation that operates independently from the organizations that gave birth to it. The goal of the organisation is to deliver the project on time, within budget and with an acceptable level of quality, guided by the Risk/Reward scheme. The alliance members, including the client, make all decisions in relation to the project. In case of a dispute the members are kept to solving this internally. This can be done through multiple alternative dispute resolution methods [21].

The main contractors role during the process of construction is mainly focussed at facilitating and coordinating the production process. Subcontractors carry out most of the production nowadays [1]. Most subcontractors are contracted by the main contractor through traditional contracts, which means that the subcontractors are only asked to deliver as certain amount of production and not to utilise their specific knowledge for the benefit of the project. In project alliances it is possible to utilise this specific knowledge by integrating the subcontractor into the alliance [20]. By making the subcontractor part of the alliance, the subcontractors' profit will also be part of the Risk/Reward scheme, thus stimulating the subcontractor to collaborate with the alliance partners to deliver more overall value to the client [20]. This way specific knowledge of the subcontractor, which can have a decisive role in the project, can be integrated into the project.

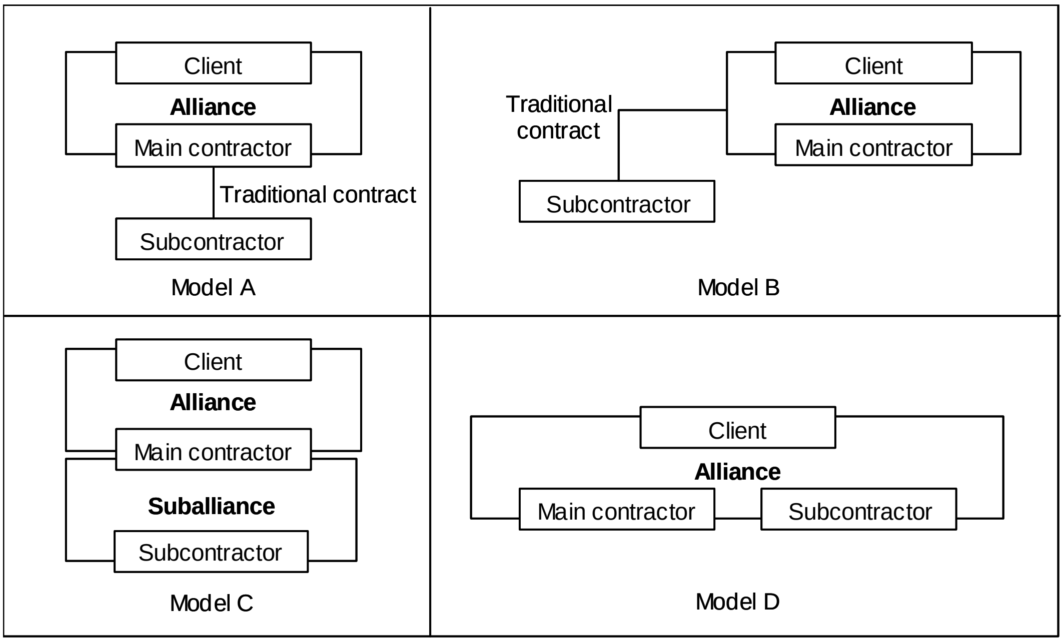

Figure 6: The position of the subcontractor in relation to the alliance [Based on 7, 20]

The position of the subcontractor in respect to the alliance can be realised multiple ways, these are [7] (see figure 6):

A. Subcontractor outside the alliance and under the responsibility of the main contractor (traditional contract);

B. Subcontractor outside the alliance and under the responsibility of the alliance (traditional contract);

C. Subcontractor as part of the alliance through a sub-alliance between the contractor and subcontractor;

D. Subcontractor as a full member of the alliance.

Model A and B represent the more traditional position a subcontractor can have in the building process. Models C and D represent possible ways to integrate the subcontractor into the alliance. In model C the subcontractor remains under the control of the main contractor, but will share in the possible risks, losses and profits of the alliance made on a particular part of the project (for instance the steel construction) for which the subcontractor is contracted. When the subcontractor is responsible for a large portion of the total work or the subcontractors' work can be seen as a critical part of the project, model D can be an option. In model D the subcontractor is part of the alliance as a full partner, this way the subcontractor will share in the full risks, losses and profits of the alliance. This will stimulate the subcontractor even more to work closely together with other partners in the alliance in order to deliver maximum value and thus receive maximum profit.

Models C and D can also be applied for the integration of suppliers and consultants with the alliance. This integration makes dynamic control of the supply chain reach far further than just the contractor.

7. Discussion and Conclusion

The project alliance delivery method can be seen as a first direction to achieve dynamic control of a project's value. It is done by the coupling of the value of a project with profit of the value supplying parties through the so-called Risk/Reward scheme.

The Risk/Reward scheme puts an incentive on the value of the value demanding parties. The incentive should be placed in such a way that there will be no profit for the value supplying parties as this value reaches minimum acceptable levels. Extra profit can be gained by supplying extra value to the value demanding parties. This way the Risk/Reward mechanism supports the concept of dynamic control, because the value supplying parties will always search for solutions that will optimize their profit and thus stimulate the delivery of extra value.

One of the more important steps that have to be taken in order to make project alliances (and dynamic control) possible is to open up the development stage of a project. During the development stage value demanding and supplying parties should be able to work together on maximising the possible outcome of the project. This means that the development phase should be placed after the selection phase and that the selection should be based on the quality a value supplying party could deliver into the project.

In a project alliance demand and supply chain are integrated to the extent that they form one organisation for the duration of the project. The goal of the organisation is to deliver the project on time, within budget and with an acceptable level of quality, guided by the Risk/Reward scheme.

Subcontractors, suppliers and consultants can play a decisive role in the success of a project. In order to fully utilise their specific knowledge for the benefit of the project they should be made part of the alliance. In this way the subcontractors', suppliers' or consultant's profits are made dependent of the success, thus stimulating full dedication. Subcontractors, suppliers and consultants can made part of the alliance by the means of a sub-alliance or by making this party a full member of the alliance. By doing this dynamic control further into the supply chain is made possible.

Project alliances should be seen as a starting point from which we can further develop the dynamic control of construction projects. In order to develop dynamic control into the lifecycle of a building, further research is necessary. The first direction given is that dynamic control can only be fostered by procurement methodologies that leave room for value being developed in a dialogue between value demanding and value supplying parties. Selection methodologies will need to address other issues like fit for project, alliance thinking, collaboration, creativity, past performance and so on. In order to be able to select a contractor (or other party involved in the project) that is able to deliver maximum value for the value demanding party. Performance based procurement [18] for instance aims at selecting high performance contractors who deliver value against competitive prices.

Integrated project delivery asks for high performers who are able and willing to collaborate with the client in order to deliver maximum value to the client and optimise the possible profits. This could be further stimulated by having the alliance deliver multiple projects instead of one. This implies the formation of a strategic alliance [16]. By having multiple projects being developed by the same alliance, the partners will be more willing to keep good relations between each other. Further, the learning effects of the first project could be stored into the alliance and utilised for the benefit of the following (similar) project. Not only will the organisation of the alliance will become better structured and adjusted, mistakes made in the first project will be prevented in the following projects.

This concept should be further developed over the lifecycle of a project. Data about the lifecycle costs and performance of a building should be gathered and used by the construction of the following similar project. When this is done within a strategic alliance, the possible benefits during construction period and the lifecycle can be utilised fully to the benefit of the value demanding parties.

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Procurement Methods are Not Set-up for Lowest Cost!

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Abstract

This paper argues that general contractors' procurement methods in the Finnish construction industry are generally focusing only on a small part of cost, namely, on the seller's margin of the product price. The margin is often only a few percentages in some cases it may be up to 15% of the product price. The rest and the major part of the product price consist of labour and material costs, and overhead. The general assumption is that the market forces suppliers constantly to reduce labour, material, and overhead cost in order to stay competitive hence it is enough if buyers of building products such as contactors and owners have means to identify the lowest market price. However, evidence demonstrates that in many cases buyers of construction products can significantly impact on suppliers' labour and material cost; and moreover, on the process cost. Still, current procurement methods are lacking systematic methods to address other costs than margins.

This paper proposes a framework for buyers based on Transformation-Flow-Value theory and lean methods to reduce both process and product cost during the procurement phase. Here the supplier and buyer aim in collaboration to reduce waste from the supply chain installed. Waste is a non-value adding activity such as, inventories of goods awaiting for further processing or consumption, unnecessary production, unnecessary transport of goods, defect products, design of goods and services that fail to meet user’s needs, and make-do. With help of examples in procuring wood-framed windows and pre-fabricated concrete elements, it is demonstrated that certain waste can only be reduced through supplier-buyer collaboration. The savings from the reduced waste can be significantly larger than what can be reached in traditional procurement through competitive bidding based on nominally complete plans and specifications.

Keywords: Procurement, market price, supply chain, lean construction

1. Introduction

In construction, procured material and labour can be up to 70% of project cost [1, 2]. In Finland, the large general contractors source mainly with help of annual purchasing agreements, where unit prices are set for a pre-determined time period; or through the spot market, where products and services are bought based on the prevailing availability and lowest cost. However, in both cases, when the supplier is selected, the product price is the decisive factor and the transaction cost and the cost of waste are not considered. The transaction cost consists of the cost of specifying the details of procurement contracts, the cost of discovering what prices should be, the cost of negotiating the procurement contract, and the cost of monitoring the fulfilment of contract [3]. Several studies has shown that the transaction cost can be significant, 10% or more, of the product price, e.g., [4, 5, 6, 7]

Waste is a non-value adding activity [8] such as, inventories of goods awaiting for further processing or consumption, unnecessary production, unnecessary transport of goods, defect products, design of goods and services that fail to meet user's needs, and make-do. In mid 90s, the Swedish construction company, Skanska, studied how much non-value adding cost where embedded in various material deliveries in the Swedish construction industry. In the study it was found that a large part of the cost is waste, e.g., if gypsum board cost 100 the non-value adding part of the delivery cost is 140 (Figure 1), hence the actual price of gypsum board as it reaches its final consumption on site is 240 [9].

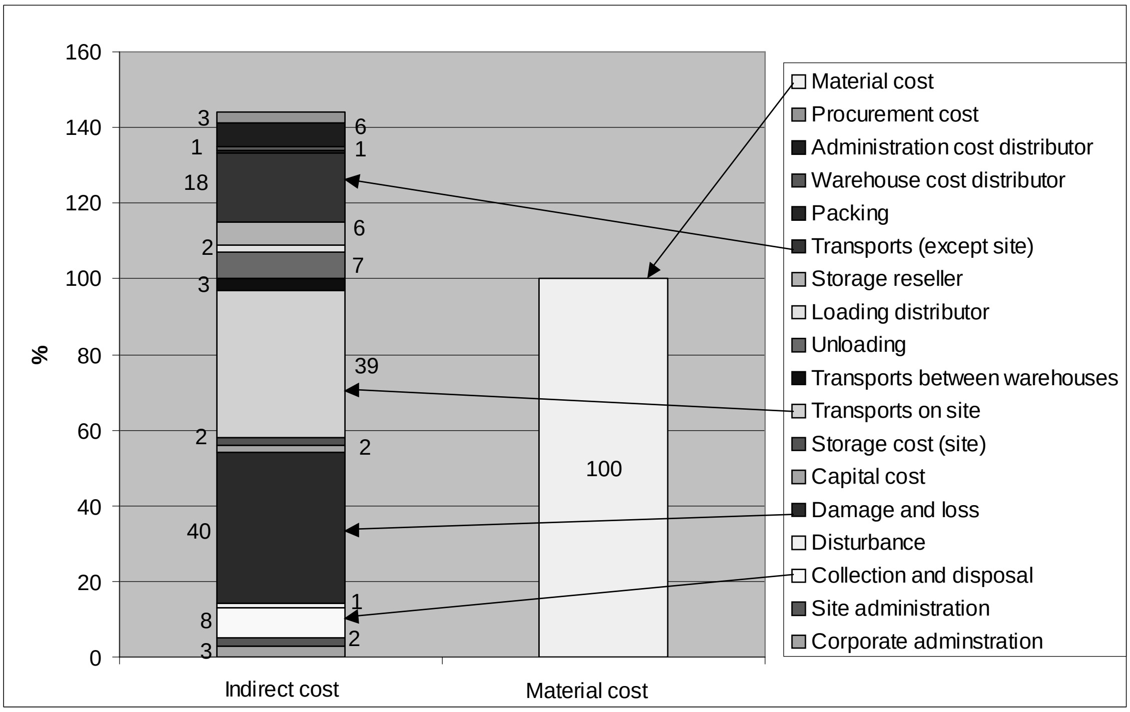

Figure 1: Indirect and direct cost for gypsum board [9]

In construction, one reason why the transaction cost and waste are poorly considered is that they are tedious to capture thus their value tend to be underestimated. Also, even if there is a sense of the magnitude of the costs; there is a lack of means to address them. The purpose of this paper is to present a framework that captures the transaction cost and waste during the procurement phase.

Next, a brief description of the key concepts, some case examples, followed by a description of the framework. Finally, the paper ends by discussion and conclusion of the preliminary findings.

2. Theory

2.1 Lean Construction

Lean construction was sparked by two main motives. First, the construction industry had long been criticized for lacking a production theory, which by several scholars, e.g., [10, 11], have been considered as the reason for poor performance of the industry. Second, the extraordinary achievements in "lean manufacturing" inspired scholars in the construction industry to rethink lean production methods and tools to project-based production, such as construction. Even if the term lean manufacturing was coined in 80s the underlying theory of lean manufacturing was not explicitly explained until Koskela [12] studied production theories in-depth. He identified at least three different conceptualizations of production that have been used, namely; transformation, flow, and value (TFV). Further, he argued that all three conceptualizations are necessary and should be used simultaneously. These concepts form the theoretical foundation of the TFV theory. According to the TFV theory, the design, control, and improvement of production should be conducted as an integration of transformation, flow, and value concepts and not as alternative concepts [12].

The concept of transformation is based on the idea that production is conversion of inputs to outputs and the goal is to make the transformation as efficient as possible. Although this concept has dominated the construction industry, it has severe shortcomings. It does not aim to reduce wasted resources and does not focus explicitly on customer requirements [12]. The flow concept recognizes that production consists of inspection, waiting, transportation as well as transformation [12]. The first three factors are non-value-added; hence, they should be eliminated. Ohno [13] and Shingo [8], who termed non-value-added tasks "waste". Ohno [13] and Shingo [8] observed that by merely eliminating waste from the production system, significant productivity improvements were achieved. The goal of the value concept is to generate best possible value to the customer, based on his requirements [12]. Value is not the same as quality. Quality is an assessment of how well customer needs are met, whereas value can be understood to also include the sacrifice to meet the needs [15] (Table 1).

Table 1: Summary of TFV theory [16]

	Transformation concept	**Flow concept**	**Value concept**
Conceptualization of production	As a transformation of inputs to outputs	As a flow of material composed of transformation, inspection, moving, and waiting	As a process where value for customer is created through fulfillment of his requirements
Main principle	Getting production realized efficiently	Elimination of non-value-added activities	Elimination of value loss
Methods and practices	Work-breakdown structure, MRP, organizational responsibility chart	Continues flow, pull, production control, continues improvement	Methods for requirement capture, quality function deployment
Practical contribution	Taking care of what has to be done	Making sure that unnecessary things are done as little as possible	Taking care that customer requirements are met in best possible manner

2.2 Procurement Based on Transformation (T)

Procurement is a process that defines what, when and how much to purchase and ensures that what is required is received timely according to the specifications [17]. Project Management Institute's PMBoK [18] identifies as the major process in procurement: procurement planning, solicitation planning, solicitation, source selection, contract administration, and contact close-out (Table 2). PMBoK's description of procurement is a based on transactional contracting. In construction the contracts are typically transactional contracts [19], where contracts are short and limited, and past or future relations between the parties are not considered [20]. PMBoK's description of procurement is a good example of the application of the transformation concept, where the focus is to transform inputs to outputs, without explicitly considering on reducing process waste and customer requirement (primary focus on contract requirements). The contract and its follow-up are the key outputs.

Table 2: PMBoK's procurement processes

Major process	Description
Procurement planning	Determine what to procure and when.
Solicitation planning	Documenting product requirement and identifying potential sources.
Solicitation	Obtaining quotation, bids, offers and proposals as appropriate.
Source selection	Choosing from among potential sellers.
Contract administration	Ensuring that seller's performance meets contractual requirements.
Contact close-out	Completion and settlement of the contract, including resolution of any open items.

2.3 Procurement Based on TFV

Procurement may generate significant amount of waste. If procurement is performed according to PMBoK, it forces upstream players to commit early to design solutions and to pursue large design batches. The design cycle time becomes long thus the probability of changes increases and the change-order process is typically tedious and disputes are common [7]. From a supply chain approach, where the product detailing, procurement, manufacturing, shipping, and site installation of the product is included (Figure 2), most of the time is pure waiting, and re-designing and re-work are common [7, 21]. The design is driven by the need for contract documents not actual site conditions. Also, it is rare that detailing, manufacturing, and site installation are performed in the same sequence and batch sizes (e.g., [22]).

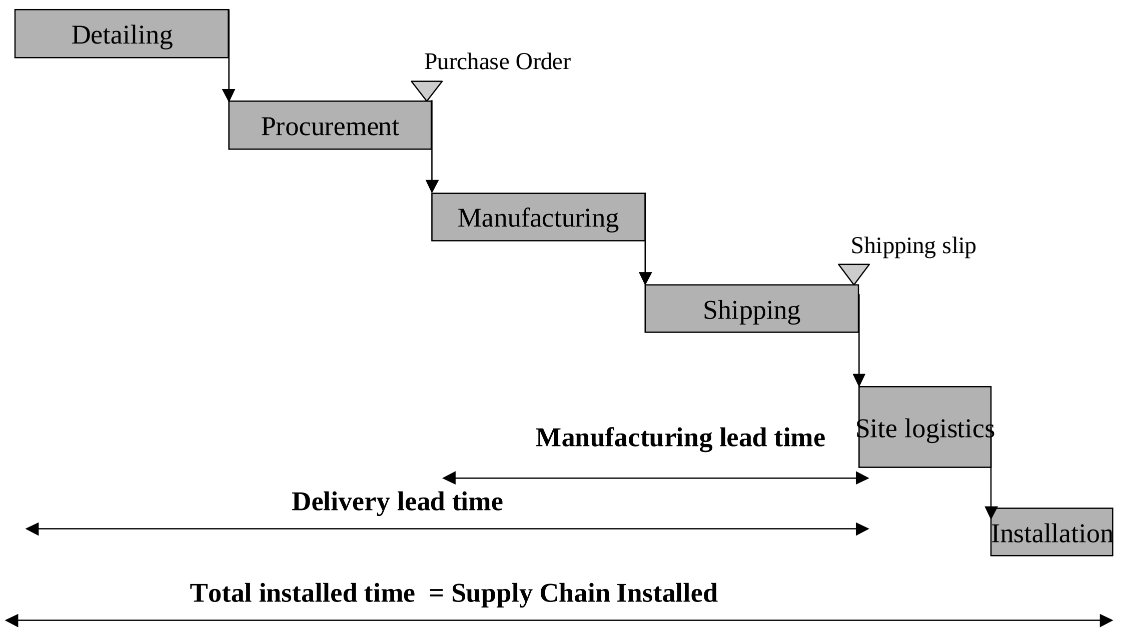

Figure 2: Phases of supply chain

This does not mean that the transformation approach is not needed rather than there has been too much focus on the transformation and too little focus on the flow and value concept. From a flow approach the procurement should be conducted so that it reduces process waste. In waste reduction, the main principles are to reduce variability and overall lead time [12]. From a value approach the procurement should be conducted so that the customer requirements are fulfilled. The nature of project-based production is iterative; where as the process progresses more information and knowledge become available. Consequently, project stakeholders' requirements sharpen and may even change. Therefore, it is of value not only to fulfil the initial requirements but also be able to fulfil by minimum waste customer requirements that result from the "organic growth" or change-orders. In summary, in procurement based on TFV, all three concepts are included, and the main emphasis would be on flow and value (Table 3).

Table 3: Procurement based on TFV

Approach	Description
Transformation	Procurement is able to efficiently turn product specification and delivery requirements to products that are ready to install.
Flow	Procurement generates minimum waste in supply chain.
Value	Procurement is able to maximize customer value throughout the project including the organic phase.

3. Case examples: Procurement based on T

The two case examples are randomly chosen without a special intention to find worst or best cases rather they are cases that probably every practitioner can assimilate to.

3.1 Wood-framed Windows

The company A has procured wood-framed windows from company B. The focus is on product price; hence, the process cost is forgotten. As a result, plenty of waste in the process is generated, which can be picked-up from the correspondence between the two companies:

- Building permit April 2004 (master schedule and project completion date set)
- 27.5.2004, company A informs company B windows needed beginning of September, 2004 (Company B makes capacity reservations at the plant)
- 12.8.2004, company A informs company B windows needed beginning of December, 2004 (Company B re-schedule capacity)

- 2.11.2004, company A informs company B windows needed beginning of December, 2004

- 3.12.2004, 200 windows ready by company B.

- 11.12.2004, company A informs company B windows needed beginning of January, 2005 (Company B runs out of storage space)

- 14.12.2004, windows are delivered to logistic centre

- 11.01.2004, company A informs company B windows needed mid February, 2005

- 19.01.2004, window installer expects installation starts, mid March, 2005

The original schedule was 27 weeks wrong and the windows waited 19 weeks in "logistic centre". The supply chain installed was 84 weeks and manufacturing lead time 4 week. The process cost was significant but never addressed.

3.2 Pre-fabricated Concrete Walls

This project was on a strong schedule pressure and the structural and the MEP engineers were working significant overtime and in an irrational engineering sequence to meet the milestones set during the procurement by company C (contractor) and company D (supplier). As result, there were expensive design details, particularly caused by lack of time during detailing; and waste, particularly waiting (Figure 3, Figure 4). Interestingly, some pre-fabricated elements that waited (element details and ready elements) 100 days or more; and still, there was a rush! This is another example where procurement was based on T and product price but the process cost was ignored. The design paid a price but also company C, the buyer, because of the expensive design solutions and indirectly for the capital tied in ready products waiting to be installed.

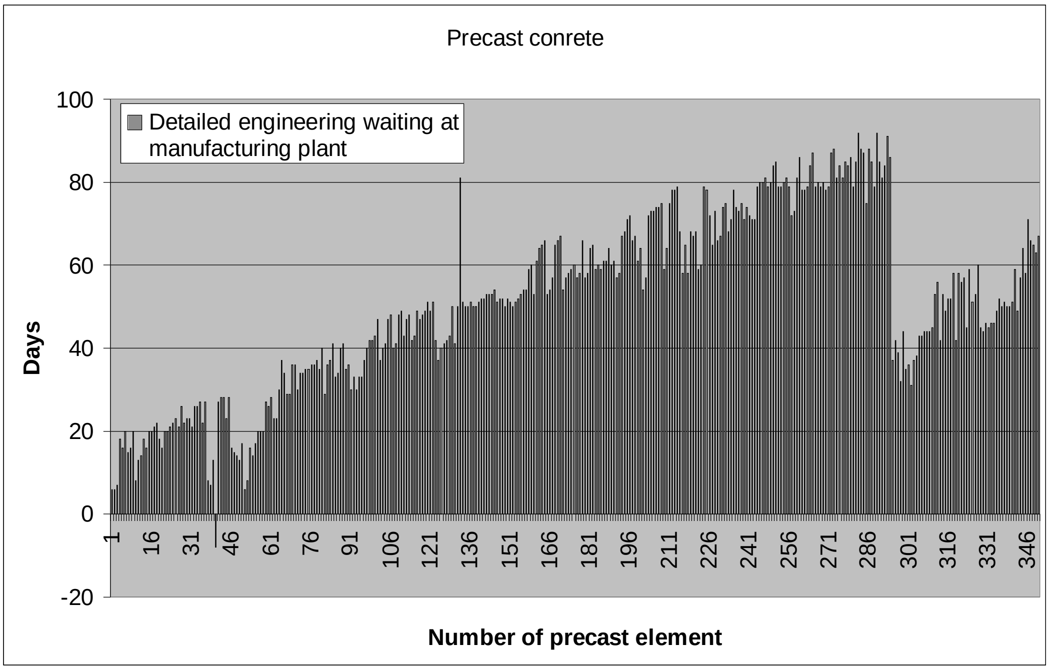

Figure 3: Waiting of detailing at manufacturing shop

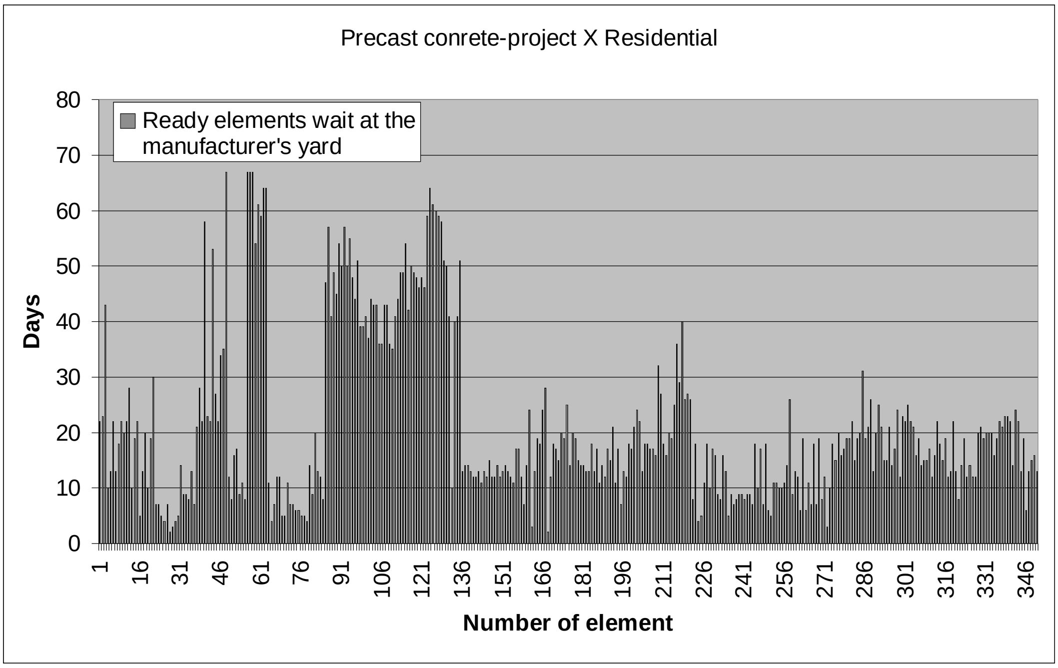

Figure 4: Waiting of ready elements at the manufacturer's yard

4. Framework for "Lowest Cost" Procurement

This section provides an alternative to procurement based on T. The alternative aims to consider TFV simultaneously in procurement. The cost scope of the framework is either Total Installed Cost (TIC) or Total Cost of Ownership (TCO), depending on how much contractors and suppliers are able to influence customer requirements[1]. In TIC, the cost of installing the equipment to its final location in the building is considered along with purchase price, logistics cost, and transaction cost (e.g., the time and effort needed to exchange data between the buyer and the supplier during design, detailing, on-site assembly, and start-up). TCO is the broadest definition of cost. It includes transaction costs product purchase price, shipping cost, operation and maintenance cost, and disposal costs [21]. The framework of the "lowest cost" procurement is described in Figure 5. Essential is that the procurement process is designed, controlled, and continuously improved.

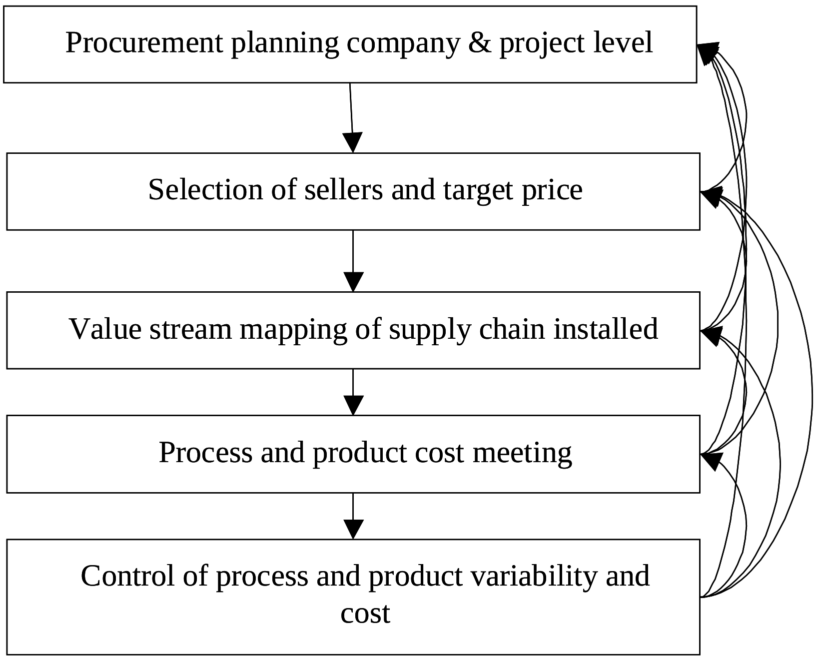

Figure 5: Framework for "lowest cost purchasing"

4.1 Procurement Planning Company and Project Level

The procurement planning is separated between company and project level so that innovation and volume can properly be addressed. On company level, procurement planning is conducted on those items, where multiple projects will benefit, e.g., where product innovation and close co-

[1] In some instances the building code, municipal, and owner may have defined specification prior to contractor or supplier involvement; therefore, TCO may not always be fully applicable.

operation between supplier and contractor are needed, and where purchasing power of multiple projects can be applied. Project level planning addresses project specific needs, what is needed and when.

4.2 Selection on Sellers and Target Price

The selection of suppliers is based on supplier reliability and TIC or TCO. The reliability is described in sub-section 4.5. The target price of a product or service is set in prior to the value stream mapping. The target price is based on past projects, or in some cases, a supplier is consulted.

4.3 Value-stream Mapping of Supply Chain Installed

In value-stream mapping each task from specifying the product to installation (Figure 2) is in detailed mapped out (see [7] for detailed value stream mapping). The mapping provides a tangible opportunity to address flow and value issues. In mapping important characteristics are the visualization of hand-offs between organizations by clearly separating organizations from each other and the use of a minimal amount of symbols for clarity. Besides tasks and their inter-dependencies, inputs and outputs, also time is mapped out. The time mapping includes the lead time of the supply chain installed and each tasks duration.

4.4 Process and Product Cost Meeting

After the target price is set and the value stream mapping is completed, both product and process costs can be estimated. The process cost is calculated from the labour hours consumed in the process excluding manufacturing or installation hours. Based on the estimated process and product cost process participants will meet to find ways to reduce both product and process costs. Besides the contractor and supplier the meeting often requires a representative of the particular engineering discipline and/or architect depending on the purchased item.

4.5 Control of Process and Product Variability And Cost

In order to continuously improve the procurement and to lower TIC the actual procurement process and installed product is measured and compared to the planned. The root causes of variability is captured and used to control variability in future procurement initiatives.

5. Discussions

The author is currently working with an architect, a contractor and a window-frame manufacturer and installer according to the proposed framework. Currently the team has advanced to the forth stage, process and product cost meeting. So far, the contractor has chosen wood-framed windows to be a company level purchase item, where innovation and consolidating company wide volumes are considered beneficial. The seller has been identified and target prices have been set based on historic data. The value stream mapping has been completed. So far, with help of object-oriented product libraries, the information flow between parties has significantly improved as well as the task durations for the stakeholder, e.g., the architect needs only a third of the labour hours required before for the detailing, and the procurement needs only a tenth of the labour hours required before in purchasing. Currently the team is working on finding means to reduce more waste and product cost (manufacturing). The team has identified major opportunities in reducing waste thus increasing the productivity in the site installation. A major issue is to share real-time production schedules between the stakeholders and to increase reliability. This requires close co-operation among the manufacturer, installer, and contractor. The major challenge has been the slow pace of change. Even if there are good ideas that the team has found, the implementation of these ideas to multiple organizations is tedious. Also, although success is achieved in one project it still does not mean that other project teams will change their current practice.

6. Conclusions

In the Finnish construction industry, it is not typical that transaction and process cost (waste) are considered during the procurement phase. One of the reasons is that procurement is based on the transformation concept. As a result, there seem to be a significant opportunity to reduce procurement cost that goes far beyond in just cutting suppliers' margins. A framework was proposed to address also the flow and value concepts during the procurement phase. Key parts of the framework are value stream mapping and control of variability. Although the framework has been only partially tested and the framework may still change as it is applied, the preliminary results have been encouraging. There has already been significant reduction in transaction cost. Currently, the target is to reduce waste and product cost of the wood-framed windows. This may require moving from transactional contracts to relational contracts.

In addition to wood-framed windows, the author is applying the proposed framework for the MEP and site prep supply chains. However, these studies are still in an early phase. Future research is needed to better understand how flow and value concepts can be used during the procurement phase. Also, more data needs to be collected about transaction cost and waste caused by procurement. It is time to fundamentally re-think the procurement in the construction industry, and continuously work for lower cost, and not just hunt for "low" spot market prices.

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Barriers and Opportunities for Offsite in the UK

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Abstract

The UK still falls behind most equivalent economies in terms of the take-up of industrialisation in construction and techniques such as offsite construction. Interest in the UK in industrialisation and offsite has recently been increasing however, partly attributable to the increased demand for housing, and pressure by Government and industry to improve the performance of the UK construction industry, particularly its efficiency, quality, value and safety. This paper discusses the views of the UK construction industry on offsite. This work has been conducted by Loughborough University as part of a DTI and UK industry funded research programme on offsite technologies and prefabrication called prOSPa (*promoting Off-Site Production applications*).

This paper presents results from a recently completed questionnaire survey on offsite and prefabrication in the UK. A preliminary survey was used to guide and inform the development of a main survey involving three different questionnaires in order to target the three main groups of stakeholders involved with offsite - suppliers/manufacturers, contractors and designers/clients.

More than 90% of the respondents had used some type of offsite or prefabrication in at least one of their projects. Demand for offsite is clearly increasing in the UK and nearly three quarters of the suppliers surveyed thought that take-up of offsite by industry was increasing in their sector. The biggest advantages of offsite compared with traditional construction were thought to be the decreased construction time on site and increased quality. The belief that using offsite is more expensive is clearly the main barrier to its increased use.

Keywords: Offsite, offsite production (OSP), survey, questionnaire, prefabrication, industrialisation

1. Introduction and Background

This paper investigates the views of the UK construction industry on offsite production and technologies. It provides an indication of the opinions of the different sectors within the industry, including clients, designers and contractors, as well as the suppliers of offsite systems and components. Due to the fragmented nature of the UK construction industry it is not practical to assess the views of every organisation in every sector and so this study aims to provide a snapshot of the UK construction industry's views on offsite at the current time.

This paper is based upon research carried out by Loughborough University as part of the DTI and industry funded prOSPa research programme, which commenced in July 2003. The prOSPa consortium is composed of Co-Construct members (BSRIA, CIRIA, The Concrete Society, SCI and TRADA Technology) and Loughborough University. The programme aimed to promote appropriate applications of offsite and thus help improve the performance of the UK construction industry.

Although interest in offsite has been increasing in this country in recent years, the UK still falls behind most equivalent economies in terms of the take-up of modern methods of construction (MMC) such as offsite. This increased recent interest in offsite in the UK is partly attributable to the increased demand for housing and to pressure by Government and industry to improve the performance of the UK construction industry, particularly its efficiency, quality, value and safety.

There is almost a consensus amongst major developers over the need for more prefabrication in the future, in contrast to the actual amount employed, and it is the public sector client groups that are currently leading the way in the introduction of radical new systems [1].

For this study, offsite is defined as the manufacture and pre-assembly of components, elements or modules before installation into their final location [2]. Many terms have been used in the past to define and describe offsite, and many of these are still used today, including Off-Site Production (OSP), Off-Site Fabrication (OSF), Off-Site Manufacturing (OSM), Off-Site Construction (OSC), pre-assembly and prefabrication. This plethora of terms can at first be confusing for both the non-expert and expert alike, and so for this study we used offsite.

2. Methodology

The data for this study was obtained from four main sources of data:

1. a detailed review of existing recent surveys and publications on the subject;
2. a preliminary questionnaire survey of six organisations;
3. a main questionnaire survey of 75 UK construction organisations, including clients, designers, contractors and offsite suppliers and manufacturers;
4. a workshop held on the 6th July, 2004 by the prOSPa Programme Steering Committee to debate and refine the main findings of the survey.

Three different questionnaires were used for the main survey, one for clients and designers, one for offsite suppliers and manufactures and one for contractors. Although the majority of the questions were the same, a proportion of the questions were specifically targeted at the different industry sectors. 75 main survey questionnaires were completed and returned, including 39 from clients and designers, 13 from contractors and 23 from offsite suppliers and manufacturers. The types of organisation who participated in the main survey are shown in Table 1.

Table 1. Type of organisation.

Organisation type	% of respondents
Client / end user	27
Specialist supplier	24
Other	24
Main contractor	19
Architect / Designer	13
Specialist consultant / designer	12
Project / Construction Managers	8
M&E consultant / designer	4
Maintenance contractor / FM	1

Note: Some respondents selected more than one category.

The main '*Other*' types of organisation listed by respondents included multi-discipline consultants, modular building manufacturers and specialist sub-contractors.

Several other studies from the last three years have examined different aspects of the offsite industry in the UK and the results of these reports have also been included within this study where relevant [1, 3, 4, 5].

3. Results

3.1 Respondents Experience of Offsite

The overwhelming majority of the respondents from all the sectors had used some type of offsite in at least one of their projects (Table 2). A very small proportion of the client/designers had not used offsite before and 8% of the contractors surveyed were not sure if they had or not.

Table 2. Percentage of respondents who have used offsite on any of their projects.

	% of respondents	
	Clients/designers	**Contractors**
Yes	97	92
No	3	0
Maybe	0	8

Figure 1 shows the type of offsite product or system which is most commonly considered for construction projects by the clients and designers, and contractors in this study. Most of the types of offsite were used by more than half of the clients and designers surveyed, with framing systems, volumetric modular buildings, cladding systems and bath/toilet/kitchen pods all being used by approximately 70% of the respondents. More than half of the contractors surveyed had also used most of the types of offsite listed, with the exception of volumetric modular buildings and building services, which had been used by less than half of the contractors surveyed.

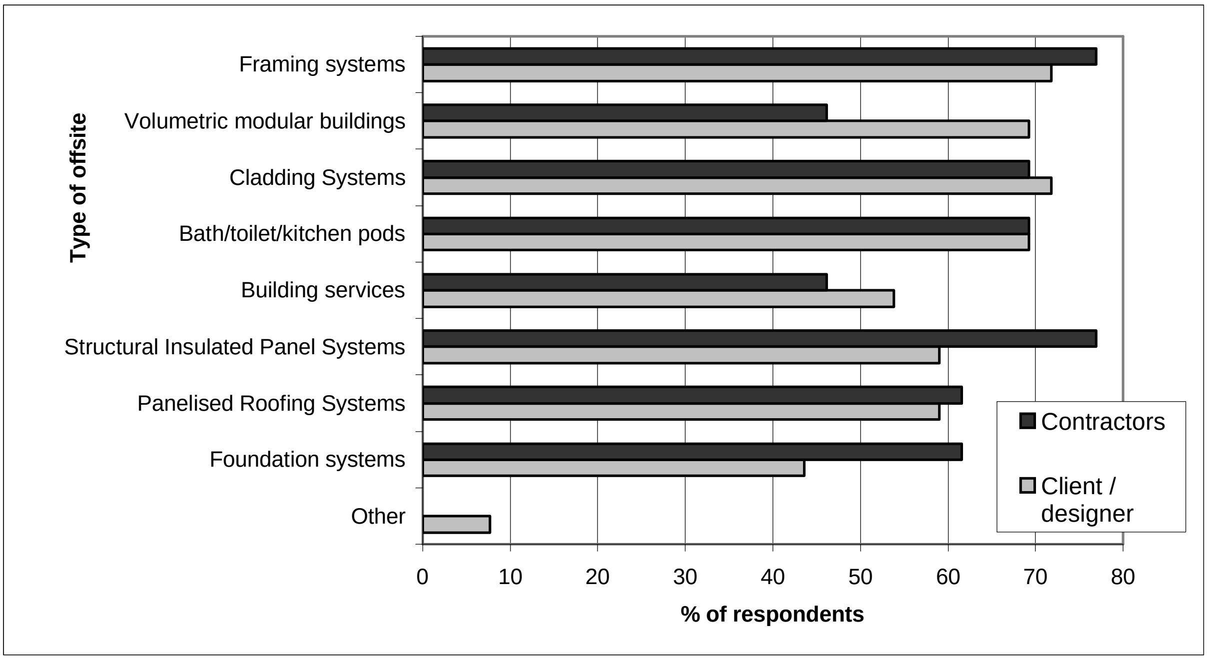

Figure 1. Type of offsite most commonly considered for projects.

3.2 Advantages, Barriers, Drivers and Take-up of Offsite

The majority of clients and designers surveyed (73%) claimed that they were sufficiently aware of the relative advantages and disadvantages of offsite over traditional construction, compared with just over half (54%) of the contractors surveyed. However, less than a third (30%) of the suppliers questioned thought that their customers were aware of the relative advantages and disadvantages of offsite over traditional construction.

This difference in awareness and knowledge of offsite is a frequent source of frustration for suppliers, with customers believing that they are aware of the relative advantages and disadvantages but suppliers knowing, or believing, that they are not. Some suppliers believe that there is an extraordinary lack of understanding in all sectors of the construction industry for the full benefits that offsite can bring and that the general understanding of offsite to some people just means volumetric modular boxes, usually grey. Many customers in the industry routinely use products and methods such as precast concrete without appreciating that this is a form of offsite. Conversely, some contractors complain that suppliers are not always fully aware of how tendering works in traditional construction, what the price means in contractual terms, and the importance of early notification if anything is done in the design development that will cause costs to rise.

The biggest advantage of offsite compared with traditional construction is thought to be the decreased construction time on site. This was stated by about 90% of respondents, including clients, designers and contractors (Table 4). Unsurprisingly, this factor is of particular benefit to contractors, with 69% ranking this as their number 1 advantage. Increased quality also ranked highly by all respondents. A more consistent product and reduced snagging and defects were also seen as advantages by the majority of respondents, although more so by the clients/designers than by contractors. Of the remaining possible advantages, a higher percentage of the client and designer respondents selected each of the possible advantages compared with the contractors who responded. This probably reflects the higher proportion of clients and designers compared with contractors who said that they were aware of the potential advantages of offsite.

Table 3. Advantages of offsite.

Advantages	Clients/designers		Contractors	
	% of respondents	% as 1st choice	% of respondents	% as 1st choice
Decreased construction time	87	38	92	69
Increased quality	79	28	77	15
More consistent product	77	18	54	0
Reduced snagging & defects	79	8	69	0
Increased value	51	5	23	0
Increased sustainability	49	3	31	0
Reduced initial cost	44	3	15	8
Reduced whole life cost	41	0	15	0
Increased flexibility	33	0	15	0
Greater customisation options	33	3	0	0
Increased component life	28	0	15	0
Other	18	15	8	8

Much research has been conducted into the barriers, both perceived and real, that are hindering the increased uptake of offsite in the UK construction industry. The study by Robert Gordon University [1] was based upon the premise that house buyers are so strongly influenced by negative perceptions of post-war ‘pre-fab’ that they will resist any innovations in house construction which affect what a ‘traditional’ house looks like.

The main barriers found in this survey stopping clients/designers and contractors from using more offsite are presented in Table 4.

Table 4. Main barriers hindering the increased use of offsite.

Barriers	Clients/designers		Contractors	
	% of respondents	% as 1st choice	% of respondents	% as 1st choice
More expensive	67	54	77	38
Longer lead-in times	46	8	62	8
Client resistance	38	13	31	23
Lack of guidance and information	33	5	46	0
Increased risk	36	0	15	0
Little codes & standards available	33	3	23	0
Other	31	18	15	8
Negative image	28	0	46	8
Not locally available	18	5	15	0
No personal experience of use	18	3	38	15
Obtaining finance	18	3	8	0
Insufficient worker skills	21	0	23	0
Reduced quality	13	0	15	0
Restrictive regulations	13	0	31	0

The belief that using offsite is more expensive than traditional construction is clearly the main barrier to the increased use of offsite in the UK, even though a large proportion of the respondents thought that one of the advantages of using offsite was both a reduced initial cost and a reduced whole life cost (Table 4). Suppliers often argue however, that offsite is not more expensive as costs are not compared in the right manner in order to take into account advantages such as reduced on-site construction time and economies of scale [3]. This issue is also addressed by the IMMPREST (*Interactive Method for Measuring PRE-assembly and STandardisation benefit in construction*) tool developed by Loughborough University, which seeks to provide a framework for comparing solutions in a holistic manner. Other advantages such as increased quality and reduced snagging are rarely included in costings and many projects are still judged purely on first or initial cost, either intentionally or unintentionally.

Longer lead-in times were also a significant barrier to clients, designers and contractors. This was a barrier to a higher proportion of contractors however, presumably because the use of offsite could delay the beginning of the project on site.

Who usually drives the idea of using offsite for a particular project depends upon who you speak to, as can be seen in Figure 2. Clients and designers think that it is the client who usually drives the use of offsite on a project, together with the contractor, designer and architect. Contractors however, feel that it is more themselves and the architect who are the drivers. Suppliers on the other hand, think they themselves are one of the drivers, together with the client and the contractor and that the designer and architect are less so.

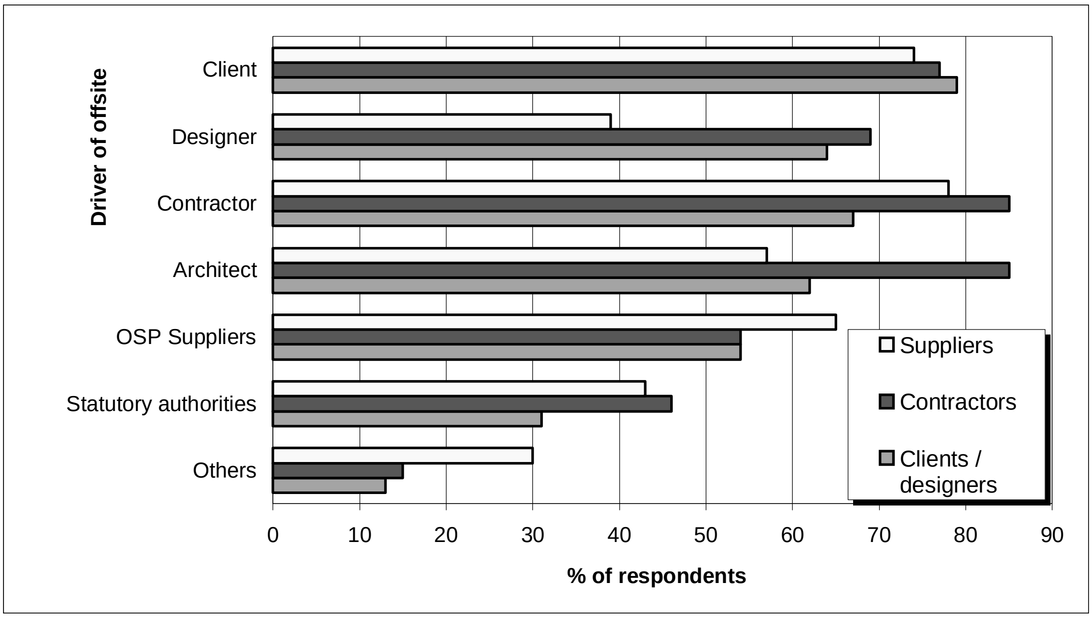

Figure 2. Main driver of offsite on a project.

3.3 Supply and Demand of Offsite

Nearly three quarters of the suppliers surveyed thought that take-up of offsite by industry was increasing in their sector, and only one respondent thought that it definitely was not. This agrees with other reports, which predict growth of 9.7% per annum (by value) by 2010 [4].

The main barriers stopping clients/designers and contractors from using more offsite were discussed earlier and presented in Table 5. Suppliers were therefore asked what means they used in order to overcome their clients' resistance to the use of offsite. The main method used was the provision of examples and case studies of previous successful uses of offsite (Table 9). The other main methods included client experience and increased partnership and marketing, all different ways of informing, educating and/or convincing the client of the possibilities and advantages of offsite. Reductions in price were only used by about a quarter of the suppliers in this survey, even though the increased expense of offsite was the main barrier to use quoted by clients/designers and contractors (Table 5). The majority of suppliers presumably sold the use of offsite on other factors such as speed of construction, quality and value rather than cost.

Table 5. Overcoming clients resistance to offsite.

Means of overcoming resistance	% of respondents
Provision of examples / case studies	68
Client experience	55
Increased partnership arrangements	55
Increased marketing / information	50
Price reductions	27
Other	23

3.4 Refurbishment

The suppliers in this survey were asked what percentage of their work was attributed to new build and how much to major refurbishment and maintenance. All of the suppliers were involved in new build, with almost 60% of the respondents being involved in new build *only*. About 40% of the respondents also supplied products for major refurbishment but only one supplier surveyed supplied products for maintenance.

When asked if the suppliers thought that there *was* a market for offsite in refurbishment in the UK, only about one third said definitely yes (Figure 4). Interestingly, this proportion was less than the number actually currently supplying products for this market. More than half of the suppliers surveyed were not sure if there was a market for this in the UK or not. This could be due to these suppliers waiting to see how the market for refurbishment develops before deciding what to do.

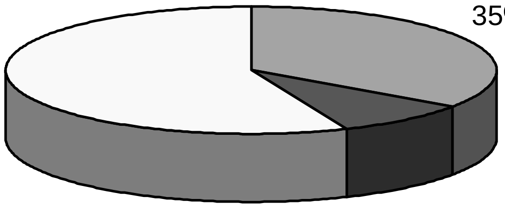

Figure 3. Proportion of offsite suppliers who thought that there was a market for offsite in refurbishment in the UK.

In recent years however, nearly half of all construction expenditure in the UK has been spent on refurbishment and repair compared with new construction. Furthermore, in the house building sector this proportion rises to approximately two thirds [6]. Refurbishment and repair is therefore a potentially large market for offsite in the UK into which it has already made some progress, but for which there is potential for significantly more. Not all of this market is suitable or practical for the application of offsite however, as a significant proportion can be classified as domestic DIY, but potential still exists for further expansion within this sector.

3.5 Labour and Skills

The UK construction industry has a historically low level of training compared with other countries and it is estimated that between 70 and 80% of the workforce in construction in the UK has no formal qualifications [7]. A large proportion of the workforce are labourers, many of them self-employed, and their skill-base is narrow and their training is limited. There is also an estimated annual turnover of between 65000 and 75000 people per annum in the UK construction industry [8].

Electricians, joiners and bricklayers were the three skills generally cited the most by all the sectors questioned as being in short supply and contributing to the increased demand for offsite products (Table 12). Contractors seem to be feeling the effects of the skills shortage as plumbers were the only trade which they felt was not increasing the demand for offsite to a significant degree. Conversely, the majority of suppliers thought that the lack of concreters, steel erectors and steel fixers contributed little to the increased demand for offsite. The other main skill mentioned by respondents which was not on the list was plasterers, which also seem in particularly short supply.

Table 6. Skill shortages contributing to the increased demand for offsite.

Skill	% of respondents		
	Client/designer	**Supplier**	**Contractors**
Electricians	65	38	67
Joiners	59	76	83
Bricklayers	44	71	58
Steel-fixers	35	19	42
Steel-erectors	32	10	33
Other	29	48	42
Concreters	26	10	50
Plumbers	12	33	8

It would seem at first that, with this general lack of skills, the UK construction industry would be perfectly placed for the increased use of offsite. Clarke [9] reports however, that a skilled workforce is required to enable innovations such as offsite to be applied. Workers here in the UK are generally not provided with an initial broad-based training after which they specialise. Instead, they are usually trained for just one role which consequently makes adapting and multi-skilling difficult, which is what is required for an increased uptake in offsite.

All respondents were asked what steps they thought could be taken by manufacturers, trade bodies and/or the Government to encourage people to enter careers in offsite in order to reduce the skills deficit. More written responses were received to this question than any other in this survey, reflecting both the importance and the far-reaching consequences of the skills deficit.

The two subjects that were mentioned most frequently were training and education and raising the awareness of offsite. Respondents mentioned that investment was needed in training and education at all levels, from school leavers through to university courses. The lack of, and need for, modern apprenticeship schemes was mentioned up by several respondents, as was the need for NVQ's in offsite and multi-skilling. Government training grants were suggested by several respondents, both for offsite manufacturers and for training colleges. Partnerships between local colleges and offsite suppliers were also discussed, as was the inclusion of offsite topics in University courses for building professionals. Raising the awareness and increasing the perception of offsite, particularly to clients and the general public, was mentioned by several respondents in order to relieve the technology of its poor historical 'pre-fab' image. This could be done by promoting and marketing the benefits and advantages of offsite more widely, both by individual companies and by the Government, and by highlighting good practice.

4. Conclusions

This paper has presented some of the views of the UK construction industry on offsite production and technologies. It provides an indication of the opinions of the different sectors within the industry, including clients, designers and contractors, as well as the suppliers of offsite systems and components.

More than 90% of the respondents from all the sectors surveyed had used some type of offsite in at least one of their projects. Nearly three quarters of the clients and designers claimed that they were sufficiently aware of the relative advantages and disadvantages of offsite over traditional construction, compared with just over half of the contractors surveyed. However, less than a third of the suppliers questioned thought that their customers were aware of the relative advantages and disadvantages of offsite over traditional construction.

The biggest advantage of offsite compared with traditional construction is thought to be the decreased construction time on site, together with increased quality, a more consistent product and reduced snagging and defects. The belief that using offsite is more expensive when compared with traditional construction is clearly the main barrier to the increased use of offsite in the UK, even though a large proportion of the respondents also thought that two of the advantages of using offsite were both a reduced initial cost and a reduced whole life cost.

Who usually drives the idea of using offsite for a particular project generally depends upon whom you ask.

Nearly three quarters of the suppliers surveyed thought that take-up of offsite by industry was increasing in their sector. The preferred method used by suppliers to overcome the resistance of their client to the use of offsite was the provision of examples and case studies of previous successful uses of offsite.

All of the suppliers questioned were involved in new build, with nearly 60% of the respondents being involved in new build *only*. Approximately 40% of the respondents also supplied products for major refurbishment but only one supplier surveyed supplied products for maintenance. When asked if the suppliers thought that there *was* a market for offsite in refurbishment in the UK, only about one third said definitely yes.

Electricians, joiners and bricklayers were the three skills generally cited the most by all the sectors questioned as being in short supply and contributing to the increased demand for offsite products. The two main methods suggested to encourage people to enter careers in offsite in order to reduce the skills deficit were training and education and raising the awareness of offsite.

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Serviceable Foundation with Truss Structure

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Abstract

A new foundation method for housing is initially developed to be preparatory to tomorrow's industrial building requiring a basis that is accurate within some millimetres. However when studying possible alternatives it was also found that the process of making a foundation could become much more efficient by changing the sequence of activities. This paper describes a pilot project to test possibilities of the new foundation method in real building practice. It was observed that this fully prefabricated foundation required less material, less building time and less organisation effort. Another major improvement is obtained by simultaneous pouring of concrete for ground floor and foundation beams. These aspects make this foundation method already advantageous in today's building, where improved accuracy is reduced to a side issue.

Keywords: accurate-foundation, efficient-foundation, reduced costs, integrated design

1. The Need for a New Foundation Method

1.1 Preparatory to Industrial-produced Large-size Building Parts

Industrial produced components will become more and more important in modern building. Accordingly it is expected that house building will tend towards the use of large-seized components (prefabricated full wall-parts) and high exactness (feasible by manufactured products). In construction however, benefits of accurate large-seize wall elements can only be fully utilized if the foundation provides a similar exactness as the applied wall-elements. Current foundation methods don't provide this required accuracy without labour-intensive adaptations. With this in view a new foundation method is developed providing high accuracy (of overall +/- 2 mm) and befitting present-day chances in construction.

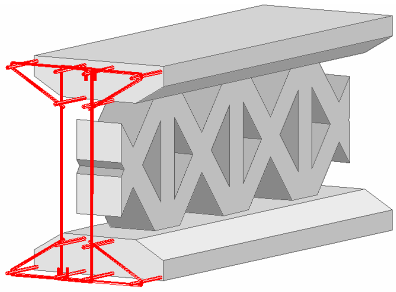

Figure 1: Outline of proposed foundation beam.

1.2 The Roman Already Knew How to Make Foundations

The way we make foundations today show many similarities with the mediaeval way of making foundations. As a matter of fact the principle itself probably goes back as far as ancient Romans since the foundation of villas and “insulae” (3-7 storied housing blocks) constructed in about 100 A.D. have “opus caementicium” beams with a kind of masonry on top to support ground floor and wall. This principle still serves as a model for present-day foundation in housing. Of course there have been numerous improvements, mainly in the last decennia, but these are primary alternatives for concrete beam or formwork, not regarding the composition itself. The original principle is designed for work done by hand and hardly changed by contemporary possibilities. As a consequence today’s foundation work is fragmented and inefficient but this is hardly noticed in building practice due to common habituation to the arisen situation.

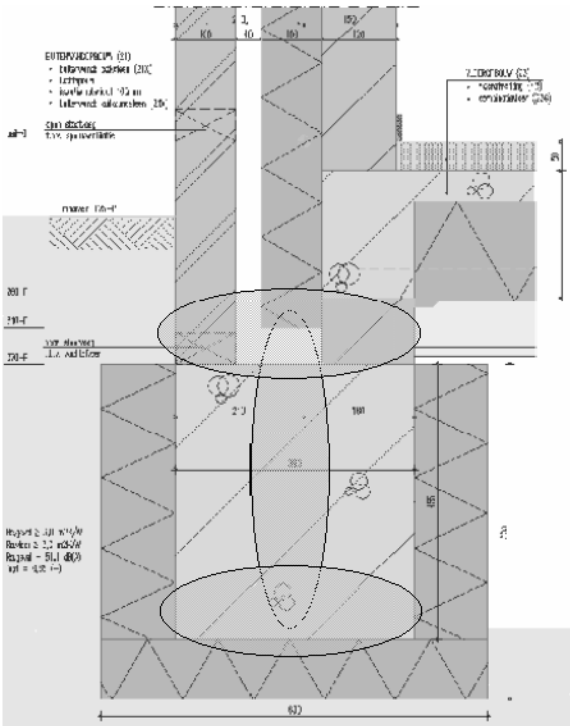

Figure 2:cross-section that is needed to meet demands of prescribed depth/width

1.3 A New Foundation as an Alternative for Inefficient Practice

Although it is obvious that the sight of a traditional foundation site displays a traditional scene with many fragmented activities few studies are known regarding alternative foundation methods. This is not explained by excellent performance of the traditional set-up as a study in 2001 observed at least 20 separate activities that have to be organised by a building company to make a “simple” strip foundation and about 25 separate activities for a regular foundation on piles [2]. With this in view the newly developed foundation method for housing was not only focussed on accuracy but also on improving efficiency. This became possible by applying fully prefabricated parts (of integrated formwork and reinforcement) and because the sequence of pouring concrete and refilling soil was swapped to get the required accuracy. This foundation principle is explained hereafter. The major improvement regarding efficiency is in excavating (excavator that dig and refill at once and thus completes all work in one activity), in omitting labour-intensive bricklaying and in reducing pouring of concrete (ground floor poured at the same time as foundation beam). Furthermore building organisation is simplified as the foundation is developed to be contracted out to a subcontractor resulting in only one activity for the building company to organise (instead of 20-25 in a traditional setting). This does not mean that difficulties are passed on to a subcontractor since the subcontractor can finish all work on site with two persons in running actions and with only four activities to organise (as sending for a plumber and ordering a truck mixer).

1.4 Inefficient Use of Material

Figure 2 shows a model regarding the effective cross-section of foundations. On top a width of 400 mm is required (to support brickwork wall and ground floor). The depth requires some 650 mm in the Netherlands to get a frost-free support. The base width depends on the foundation type: about 400 mm for a foundation on piles and 400-1200 mm for a strip foundation. The remaining I-shaped beam is almost equal strong and stiff compared to a common used rectangular beam but saves about 30% concrete.

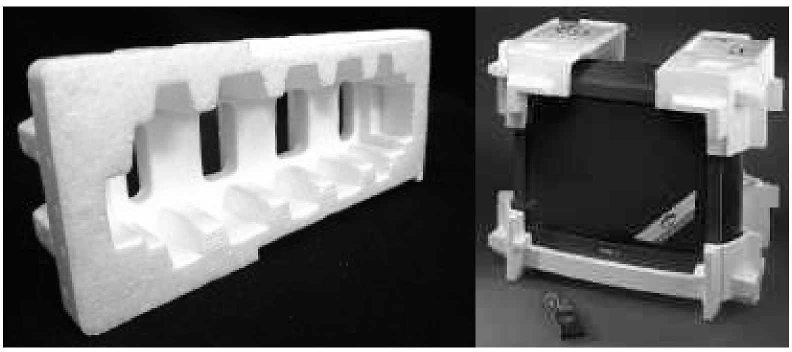

Figure 3: The idea of shells (figure 4) is picked up from packaging where EPS enables a complex form at very little expense (if mass-produced)

The detail in the background of figure 2 shows a permanent formwork made of rigid insulation material (expanded polystyrene-EPS some 100-120 mm in width) that is common used in the Netherlands. Here the thickness of EPS is governed by temporary loads of liquid mortar pressure. After hardening the EPS formwork is still useful as thermal insulation to reduce temperature drop nearby the skirting (a lower temperature might cause internal condensation). However the thickness of the permanent formwork required to resist the temporary loading is far too excessive for a later insulation use.

2. Three-dimensional Shells Used as Permanent Formwork

This paper describes a new foundation method with a typical feature of a swapped sequence of pouring concrete and refilling soil. For this purpose a permanent formwork is developed that is largely defined to resist temporary loading of refilled soil. The load of refilled soil mainly applies horizontal on both sides of the formwork. The easiest way is to link both sides of the formwork, and simply balance horizontal loads.

Linking both sides of a formwork is achieved by applying the principle of a truss structure (figure 1) to the I-shaped beam in figure 2. Forming a concrete beam as truss brings repeated spots in between diagonals, verticals and horizontals where connectors can be located to link both sides of the formwork. Just one step further is to apply three-dimensional shells with bulges in between diagonals, verticals and horizontals where both sides of a formwork can meet (figure 4). Implementing this truss structure is combined in this study with possibilities of shaping an EPS-shell in a mould. Figure 3 shows examples of three-dimensional foam elements used as packing material of a television set made of expanded polystyrene (EPS). Each element is shaped in a mould and in large numbers produced at very little expense. In packaging elements of EPS even can be very large up to (lxbxd) 2000x1200x450 mm^3 in a variety of possible shapes.

Because areas in between members of the truss (where horizontal load of refilled soil is balanced) are of reasonable size it is possible to leave openings in the EPS form (figure 4). These openings can be used to pass sewage pipes (and other pipes that have to be conducted through a foundation beam) at intervals of 0,3 m without specific adjustments during prefabrication.

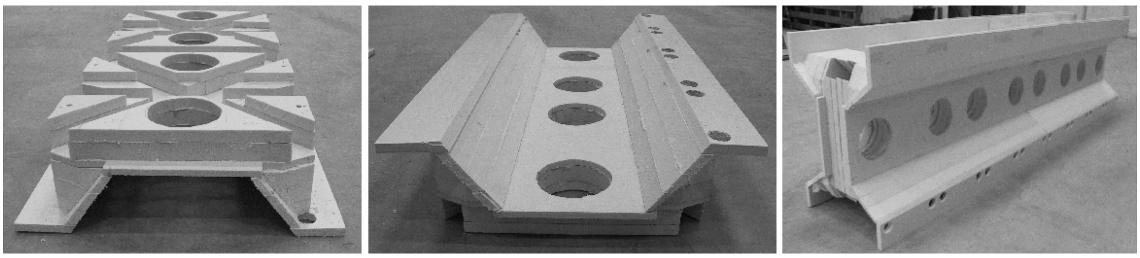

Figure 4:Three-dimensional shell as side panel of formwork. Left: seen from the inside. Middle: seen from the outside. Right: Two shells combined enabling prefabricated formwork

The three-dimensional shell (figure 4) is developed with various aspects at the back of mind:

- to save concrete by applying I-shaped beams with a truss structure put in place of the web;
- to save EPS by reducing thickness and by openings (advantageous since material costs of EPS is of the same order as material costs for concrete) ;
- to develop a standard shell fit for mass-production;
- to make solid prefabricated components out of the standard shells (put mirror wise in a row with large faces of contact);
- to have prefabricated reinforcement slot into the shells (with suitable concrete cover);
- to have openings at intervals in prefabricated formwork, enabling (sewage) pipes to be conducted through at numerous locations without special provisions (maximum Ø125 mm);
- to balance temporary loads of soil on both sides of the formwork (to save EPS, to minimize groundwork and to start with a well supported form when creating an accurate foundation);
- to have openings that can let through liquid mortar (and also have openings for compacting so the concept does not solely depend on self compacting concrete);
- to have minimum labour on site.

Another three-dimensional EPS-form is developed to be used as edge form of concrete mortar poured on top of the ground floor. This form (figure 5 and 6) will be put on top of two EPS-shells. There are two longitudinal notches on both sides to create a good-glued connection to the side of two EPS-shells that are put vertical. By means of covering rigid EPS-shells by rigid EPS-edge forms and by glued connections the prefabricated formwork becomes quite solid (if coinciding overlap of endings are avoided).

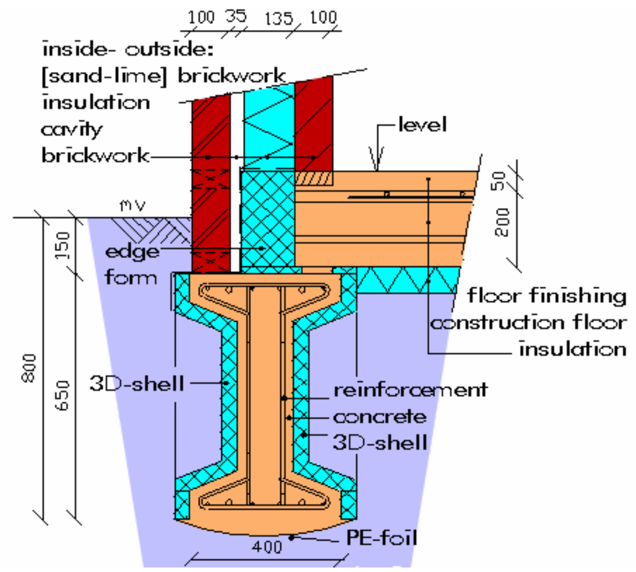

Figure 5: Detail of brickwork wall. 3D-shells, reinforcement and edge form are prefabricated. Concrete is poured on top of the floor and runs through openings of the EPS-edge form.

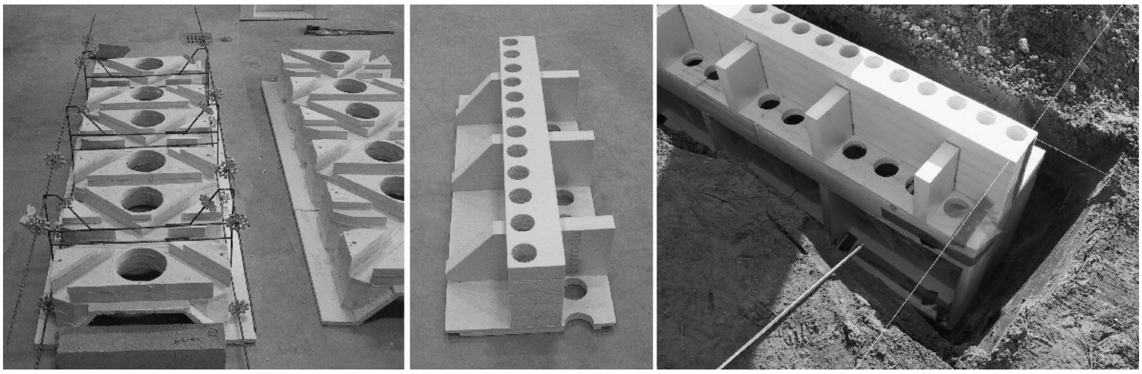

Figure 6. Left: three-dimensional shells put in a row with reinforcement put in. The formwork is closed and fixed by other shells and than turned a quarter. Another form (shown in the middle) is put on top. Middle: three-dimensional form used as edge formwork for ground floor. Right: prefabricated formwork brought to a building site and put into an excavated trench.

Although the edge form is primarily needed for pouring a ground floor (figure 10) it will also serve as cavity insulation after mortar is cured. In this respect the EPS-edge form connects the insulation underneath the ground floor with insulation in the cavity wall making a closed insulation layer (except for the small openings explained hereafter).

A third function of the EPS-edge form is to simplify progress of work for pouring a foundation beam. For this reason some openings are left in the lowest part (middle in figure 6) to let liquid mortar trough. With these openings it is possible to pour concrete mortar on the ground floor (figure 10) to fill the formwork of the foundation beam. In this way the ground floor acts as buffer when ground floor and concrete beam are poured simultaneously. And the row of openings in the top part of the EPS-edge form (as can be seen in the middle of figure 6) is meant to let through a vibrating needle for compacting mortar (as can be seen in the middle of figure 10). The vibrating needle can reach mortar at the underside of the foundation beam through verticals of the truss. Since the position of an EPS-edge form is not subjected to positions of three-dimensional shells the location of an opening and a vertical may change. For this reason a row of openings is provided so one of the openings is always located above a vertical. The practical test proved that these provisions are well applicable to get a good compacting. But the practical test also revealed that the openings turned out convenient because it provided a good visual check of the progress of filling the foundation beam.

Figure 7: The excavator makes trenches, puts formwork in and refills in running actions.

Figure 8:Left: the excavator is used to put in the prefabricated formwork. Middle: Formwork with refilled soil. Right: Next the ground floor is prepared, here a PS-combination type is used.

In developing the EPS-edge form special attention was paid to resist the effect of communicating vessels since the level of concrete mortar on the inside (floor) was some 250 mm above the level of the foundation (see also figure 5). In particular regarding the high specific gravity of mortar the different level was well considered. In the test seepage of mortar is barred by a proper glued connection of edge form to three-dimensional shell. Also the weight of mortar itself that rests upon the EPS-edge form helps to keep a closed formwork. The practical test (figure 10 and 11) showed that mortar pressure did not affect the form since seepage was not observed.

3. Practical Test

Students have carried out a small pilot project on the campus of Eindhoven University of Technology to study practical applicability of the developed foundation concept. All three-dimensional forms were made out of stacked Styrofoam sheets of 20-50 mm in width. There were two different types of EPS-shells and so also two different types of truss compositions made and tested. For the reason that the three-dimensional shape of the shell in figure 4 and 6 (resulting in the truss shown in the middle and right in figure 11) was rather complex to make out of stacked sheets the number of shells was reduced. As a result the length of this foundation beam is reduced to 1,8 metre. The main subject of research regarding this foundation beam is to test concrete filling of the quite small verticals, diagonals and under chord of the truss by practical experience.

The other type of truss (left in figure 11) was less difficult to compose out of stacked sheets so the length of this foundation beam is made 4,2 metre. In between the two foundation beams there is a small ground floor (PS-combination floor) with a span of 1,5 metre. Figure 6 shows prefabrication of formwork and putting in reinforcement. These photos do not show plastic foil that is attached to the underside of the shells (drawn in figure 5) to separate mortar from soil when pouring.

Figure 7 and 8 shows activities on site that took about 2 hours. The activities on site started with preparation of the site for building by a mini-excavator. After that the mini-excavator made a trench. Then the prefabricated formwork was picked up by the mini-excavator and placed into the trench. The prefabricated formwork had special provisions for exact positioning. The description of this falls outside the scope of this paper. When the formwork is positioned the mini-excavator immediately refills soil to fix the formwork.

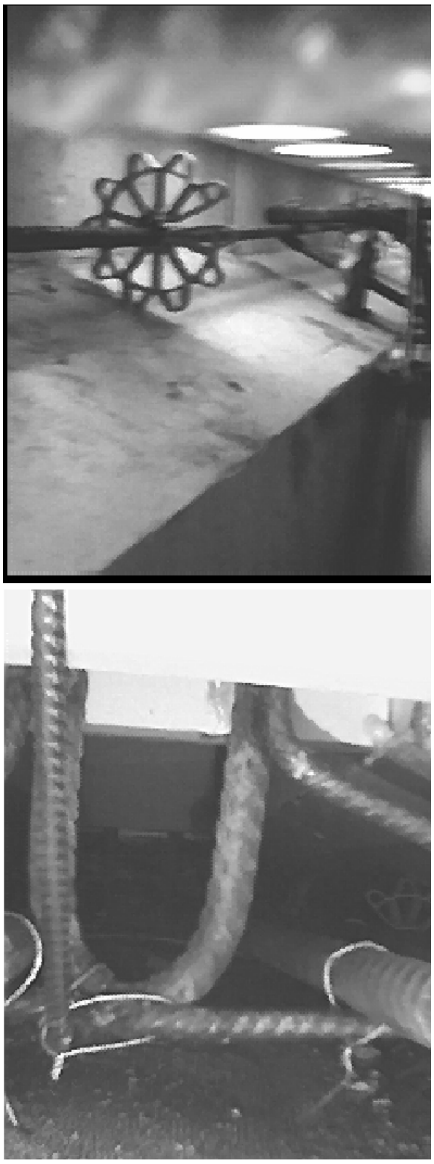

Figure 9: photo’s inside a foundation beam (after refilling soil and before pouring mortar). Above: part of top flange of I-shaped beam. Below: part of bottom flange.

The second formwork is handled in like manner followed by placing the elements for the ground floor. The next step could have been pouring concrete, but since this was a pilot project the procedure was stopped to allow inspection and documentation. Inspection of the hollow section of the formwork was carried out several days later by a small video camera that was inserted through the openings in the EPS-edge form (figure 9). These video recordings showed no signs of pushed in insulation (for instance by loading of refilled soil). All reinforcement was still in its place with sufficient cover and also the bottom reinforcement was far-off from the subsoil. The PE-foil functioned well as separator of soil and mortar. Also all displacements of the formwork were measured to study the accuracy of this foundation method.

The next day concrete mortar was poured. This took about ½ an hour and is shown in figure 10. The concrete mortar directly ran out a truck mixer on top of the ground floor. A vibrating needle and shovel was used to displace mortar to all sides to flow into the hollow section of the formwork. It was observed that mortar flew well and could be well compacted by the vibrating needle via openings in the EPS-edge form.

Figure 10:Left: Mortar is poured on top of the floor. Middle: Mortar flows into the foundation with openings that make compaction possible. Right: Finished floor and foundation.

Three days later the foundation was dismantled. Both foundation beams were dug out and brought to the laboratory (figure 11). After removing all insulation covering it was found that both forms were completely filled with mortar and irregularities were not observed. The foundation beam of 4,2 metre in length will be tested in the laboratory in near future.

Figure 11: (Left:) the foundation beam is dismantled afterwards. (Middle:) and EPS-formwork is removed. (Right:) showing a completely filled beam with I-shape and truss structure.

4. Further Continuation

Since the small-scale test indicated serviceability in real practice, a patent is applied regarding working procedure and developed forms. The next study to carry out regards building economics. Based on observations and time registrations of the pilot project a comparison will be made to find the range of possible savings as regard to traditional foundation methods. A second study regards the development of strip foundations and also of specialities. Also optimising the prefabricated reinforcement will be further developed.

It is expected that the shape of all three-dimensional forms will be adjusted by the outcome of these studies. Next aluminium moulds shall be developed to enable large-scale manufacturing of

EPS-shell and edge form. After that more practical test can be performed to study new possibilities of this foundation method.

5. Conclusions

The practical serviceability of a new foundation method for housing is demonstrated by a small pilot project resulting in savings of concrete (some 30%) and less labour on site (some 50%). All requisites are standard elements manufactured beforehand (so this foundation method is prepared for prospective mass-production) and assembled as prefabricated formwork based on specific project requirements (so also irregular lay-outs can be realised). On site all activities can be carried out in running actions by a team of two persons (excavation worker and excavator machinist). This enables foundation work to be contracted out. The result is a more efficient organisation of foundation work.

Using the ground floor as buffer when pouring concrete mortar makes progress of work easier. Furthermore this enables simultaneous pouring of foundation beam and ground floor.

The pilot project shows promising applicability of the foundation method. Yet further study and practical tests are required.

Figure 12: impression of pilot project. left-top: prefab form with reinforcement before applying edge form; left-middle: excavator prepares, levels, digs, shifts, positions and refills; left-bottom: ground floor and formwork ready for concrete; right-top: pouring of concrete (foundation + ground floor); right-middle: compacting; right-bottom: dismantled foundation.

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Section III

Productivity and Performance Improvement

Is Performance-Based Procurement a Solution to Construction Performance?

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Abstract

There are two ways to analyze the problem of construction nonperformance (not on time, not meeting the quality expectations of the owner, and not having cost increase change orders). The first is a project-specific approach, which assumes that the problems are being caused by the uniqueness of each project. This approach stresses: finding solutions in better trained personnel and craftspeople, more standards, construction management, and inspection. The other is a process approach, which assumes that the problems are being caused by the process. Performance-based procurement uses the process approach. It hypothesizes that the current price-based design-bid-build procurement process is inefficient, supports an adversarial environment, is devoid of performance information, is highly inefficient, maximizes management and inspection instead of quality control, and treats highly differential construction products and services as commodities. The Performance Information Procurement System (PIPS) was created to resolve these issues causing construction nonperformance. The results of 380 tests of construction procurement will be assessed in terms of performance. Using case studies from a variety of large clients, the results of performance will be analyzed in terms of on-time, on budget, and meeting customer expectations. Lessons will be drawn on the cost of performance, the minimization of client management and inspection, and the creation of a "win-win" relationship of best value for the owner while concurrently maximizing the contractor profit.

Keywords: Performance results, performance based procurement, construction delivery process, Six Sigma process application

1. Introduction - Construction Industry Performance

For the past twenty years, the construction industry has attempted to improve its construction performance (finishing on-time, minimizing change orders, and meeting customer's expectations). In both the United States and in the United Kingdom, overall performance has hovered between the 60% - 70% range for owner satisfaction [5, 16, 20]. The performance issues can be summarized by the following numbers:

1. 33% of projects in the US end over budget.
2. 53% of clients in the US do not want to have a relationship with the contractor at the end of construction.
3. Only 68% of clients in the UK would give a 8/10 rating or better on satisfaction.
4. Only 45% of clients in the UK stated that the costs were on target
5. Only 62% of clients in the UK stated that the projects were completed on time.

The construction industry has tried various solutions to improve construction performance. These have included continuous improvement, partnering, business process re-engineering, just-in-time construction, lean construction, prefabricated systems, and long-term partnerships. Although each solution may have improved construction operations, the general problems of nonperformance have persisted.

1.1 Influence of the Worldwide Competitive Price Pressures

The construction industry is guided by two major factors: competition and performance (Figure 1) [11]. In Figure 1, Quadrant III represents the construction industry structure before the advent of the worldwide, highly competitive marketplace. Clients or building owners selected performing designers and contractors. Terms were negotiated, and the construction was completed. Hiring was based on performance before price. These designers and contractors had highly skilled personnel and craftspeople that did their own quality control.

With the worldwide competitive marketplace, clients sought to procure a better value. The intention was to keep high quality, but increase the competition (moving from Quadrant III to II). However, the inability to identify and measure the difference of performance resulted in the awards being price based. Instead of moving from Quadrant III to II, the majority of clients moved to Quadrant I.

Quadrant I is a price-based, commodity environment. A price-based environment is only optimal when the products and services are true commodities. Commodities are described using minimum standards and requirements. The best value is the lowest price. Procuring construction as a commodity forces the contractors to provide the given acceptable performance at the lowest price. The client's representative (architect/engineer) uses minimum standards to reduce the risk of receiving a lower quality product. Figure 2 shows an example of four contractors, each with different levels of performance ability for a particular project. The specifications (input based specs (USA), not output based specifications as are common in the UK) put forward in the contract documents dictate a specific level of performance quality. To reduce costs and the chance of a successful bid, the contractors with a greater level of ability for the given project (quality, speed, expertise) lower their performance to the level of the specification. Thus, the contractors (and manufacturers providing the construction products/materials) use the minimum expectation as a maximum level (in order to maximize their profits and likelihood of a successful bid). By awarding to the lowest bidder, performance is guaranteed at only the lowest possible level, which maximizes the client's risk of nonperformance by a contractor. The resulting difference commonly causes an adversarial relationship (Figure 3) where the owner see the stated specifications as a minimum level of quality while contractors (and suppliers, manufacturers, etc.) see it as a maximum level of quality [9].

Figure 1. Construction Industry Stability

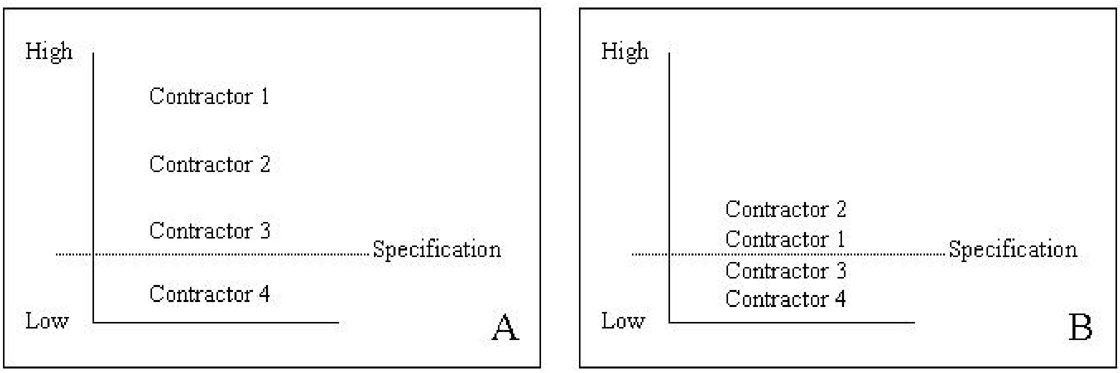

Figure 2. Impact of Minimum Standards on Performance

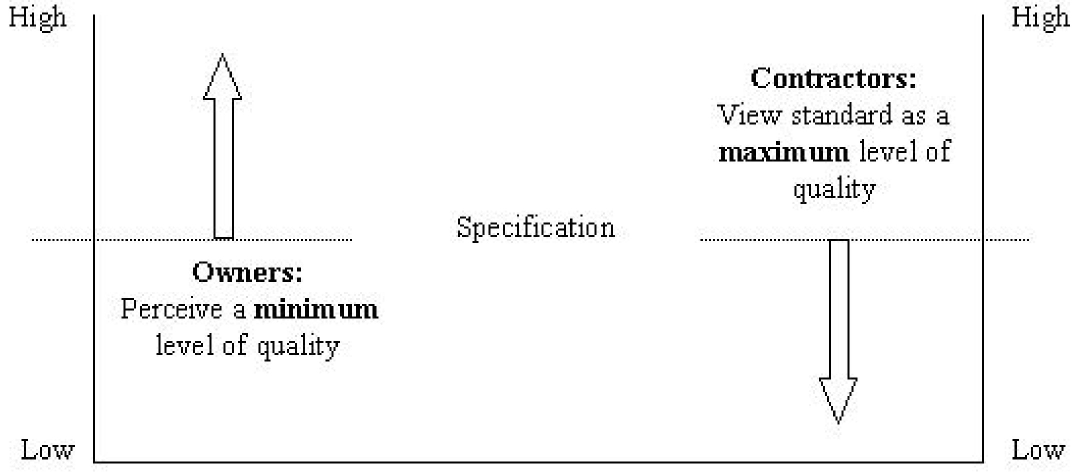

Figure 3. Owners vs Contractors: Difference in Objectives

1.2 Project Specific Approach: Construction Management and Expertise

The industry has tried to solve the adversarial, high risk environment by hiring experts who uses their expertise to differentiate every type of construction, set technical standards in each specialty; create means, methods, and material specifications; prequalify contractors; and manage, control, and inspect the contractor using technical expertise, thereby theoretically eliminating as must risk as possible. Ironically, their chief weapon, the minimum standards are a major source of risk [11]. Offering a higher performance (in a price based, Quadrant I environment) is a noncompetitive practice. This concept helps explain some of the bankruptcies of experienced construction businesses that have been in the industry for over ten years [3].

When standards are used, it forces the client to inspect in terms of means, methods, and materials (MMM). Minimum standards have no correlation to performance [2, 6, 13, 14, 21]. Standards and specifications also allow contractors who do not have experience to bid the project. The award to the low bidding, inexperienced low bidder may actually result in a higher project cost. This environment, with it poor performance results, threatens the sustainability of low-bid construction. The risk can also be identified by the high costs to sureties in both the bonding and insurance payouts [18, 15, 3]. Due to these factors, the authors hypothesize that performance has no direct correlation with awarded price. Therefore, if price does not affect specified performance, high performing contractors do not require external management and inspection. High performance contractors will quality control their own work. They minimize the performance risk with expertise and quality control.

The authors propose that by moving to a Quadrant II, performance based environment, the efficiency of the construction process will increase, minimizing performance issues. By hiring experienced personnel and contractors (which need less control, less management, and less inspection), the contractors will maximize their profit, and the owner will get best value. The authors are proposing that the effort to minimize construction performance issues using a project specific approach (Quadrant I) has proven to be inefficient and ineffective. A process based solution (Quadrant II) is required.

2. Process Based Solution: PIPS

To investigate process based performance procurement in comparison to current low-bid practices, the Performance Information Procurement System (PIPS) was designed in 1991 and has since been tested, modified, and retested 380 times over the past ten years. It is a Six Sigma based process that defines the process, measures the critical elements and the level of risk, analyzes the process using fuzzy logic, forces improvement, and controls deviation through process control (fundamentally Six Sigma's DMAIC (Define, Measure, Analyze, Improve, Control)).

The ten year, $4.2M research effort has involved the procurement of $230M of construction, and has resulted in over 80-refereed conference and journal papers. The fundamental hypothesis (construction nonperformance is a process based problem) has not been altered over the ten years, even though steps in the process has been improved through trial and error.

2.1 Research Hypothesis

Research Hypothesis:

1. Construction performance is mainly a process issue.
2. The critical element is identifying and competing performing contractors.
3. Management/control by the owner should be minimized [4].
4. An efficient environment will lower cost, deliver best value for the owner, and maximize the contractor's profit.
5. Risk should be minimized by contractors rather than clients.
6. Prequalification is only used when the process is price based.

Under the above hypothesis, PIPS was formed and is composed of five major filters of procurement (contractor selection) that seek to test the hypothesis. These major components or filters of performance based procurement are:

1. *Identification of past performance*. Past performance includes frequency of on time completion, minimal change orders, and high customer satisfaction of critical project performance elements (general contractor, site superintendent, project manager, and mechanical, electrical, waterproofing and other critical subcontractors).

2. *Project specific capability*. This is defined as the capability to identify, prioritize, and minimize the risk of the project in the non-technical terms of cost, time, and quality expectation.

3. *Competition based on performance (past performance and ability to minimize risk) and price*. The prioritization is done using a multi-criteria decision making model, which minimizes risk of nonperformance by giving credit to the identified critical past performance elements (recorded values of filters one and two). This model does not penalize values which are near the mode, but penalizes values that are below the mode. The processing of values forces contractors to provide their best value, and compete with every other best value, resulting in a two step best value process.

4. *Pre-award phase*. The best value contractor (as identified by the multi-criteria decision making model) must minimize the risks identified by all competitors. They must coordinate the requirements between critical elements, clarify or seek clarification on the project. The contractor will then sign a contract that includes their risk minimization plan, the intent of the owner, and all clarifications.

5. *Construction*. The contractor is forced to manage the project in terms of risk. The contractor passes risk information (affecting cost, time, and quality expectation) to the client's representative.

6. *Measurement of performance*. The project will be rated after completion. All critical elements of the general contractor's team will receive the same performance rating. The rating becomes up to 50% of the critical element's future performance rating.

3. Testing – Application of PIPS

Testing of PIPS was accomplished via its application on real projects for contractor procurement. Testing has been conducted over a ten year period in the public and private sectors for the following clients: Intel, Motorola, Boeing, Burr-Brown, International Rectifier, Honeywell, State of Wyoming, US Army Medical Command, Federal Aviation Administration, State of Utah, United Airlines, State of Hawaii, University of Hawaii, State of Georgia, Wyoming National Guard, Dallas Independent School District, Denver Hospital Group, Harvard University, and the US Coast Guard.

Over 380 tests and $230M of construction projects were procured using the PIPS system. The overall performance results of PIPS tests were:

1. No evidence that the first cost of the performance-based awards was more expensive than the costs of the low bid award. The Civil Engineering Unit of Oakland, CA of the US Coast Guard (USCG) concluded, via a cost analysis of PIPS awarded projects and non-PIPS awarded projects for the USCG, that PIPS represents a savings as large as 19% for a project's life cycle costs compared to low-bid or non-PIPS procurement [17].

2. PIPS showed 98% performance, where performance is given as projects that were delivered on time, with no contractor generated cost change orders after the pre-award phase, and

high customer satisfaction. This is in comparison to the documented performance of 60 – 70 percent performance of construction in both the United States and the United Kingdom.

3. Increased performance of contractors over time or in comparison with their performance in the low bid environment.

4. Contractors performing to a higher level in the PIPS environment than in the low bid environment. This includes perceived higher performance of the same contractors in the PIPS environment than in the low bid environment.

5. Construction management minimized up to 80%.

6. Minimized means, methods, and material details in design specifications.

7. Risk of designers was minimized due to the two levels of constructability review (business level review in the risk identification filter and detailed constructability review in the pre-award phase by the best value contractor).

The first repeat user of PIPS was the FAA Western Region (50 storm damage repair projects ($4M)) and the FAA provided no technical specification to the contractor. PIPS allowed the FAA engineering requirements group to increase the amount of work procured by 300 percent. Projects included building repairs, road repairs, and electrical and mechanical systems repairs. All the projects were finished on time, without change orders, while satisfying the clients.

United Airlines (UAL) was the next repeat user of PIPS (results shown in Table 1, where the owner rated certain items on a scale of 1-10 with 10 being the highest (most favorable)). As in the FAA projects, technical specifications were minimized. The process was tested on roofing, painting, waterproofing, flooring, abatement, and renovation/remodeling projects. The speed, efficiency, and minimized effort of PIPS decreased the overhead of construction delivery allowing more of the funding to go into construction.

Table 1: United Airlines Performance Based Results

NO	Criteria	Results
1	Total number of projects	32
2	Award Cost	$ 12,750,000
3	Low-Bid System of contracting. (Owner scale rated 1-10, 10 is max)	3
4	Performance Based System of contracting. (Owner scale rated 1-10, 10 is max)	9
5	Percent satisfied with PIPS	100%
6	Overall quality of construction using PIPS (Owner scale rated 1-10, 10 is max)	9
7	Percent of users that would hire the contractor again	100%
8	Percent of projects that finished on time	100%
9	Percent of projects that finished within budget	100%
10	Percent of projects with no change orders	100%

The State of Utah projects were the first large multi-million dollar projects (6 projects, $80M budget, the largest being $53M Olympic Village, Phase II). Due to the State's requirements, the projects had to be run without the most critical component of PIPS, the pre-award phase. Even though the capability of the process was limited, PBSRG ran the modified process to determine if PIPS could be used successfully on large projects with multiple subcontractors. The results were the best results (Table 2) at the State of Utah in ten years [1]. Without the pre-award phase, the contractors were not forced to find mistakes in the design documents before construction award. In the only project that was not completed on time or without change orders, the user stated that architect missed too many items for the contractor to cover [7]. The results reinforced the importance of the pre-award phase. The largest project, the $53M 2002 Olympic Village Housing project was awarded to the low bidder.

Table 2: State of Utah Project Results

NO	Criteria	Results
1	Total number of projects	5
2	Award Cost	$ 80,506,376
3	Budget	$ 85,770,000
4	Percent Under Budget	7% Under Budget
5	Low-Bid System of contracting. (Owner scale rated 1-10, 10 is max)	4
6	Performance Based System of contracting. (Owner scale rated 1-10, 10 is max)	9
7	Percent satisfied with PIPS	90%
8	Overall quality of construction using PIPS	9.2
9	Percent of users that would hire the contractor again	100%
10	Percent of projects that finished on time	80%
11	Percent of projects that finished within budget	80%
12	Percent of projects with no change orders	100%
13	Number of companies that were surveyed on past performance	357

The State of Hawaii ran the most projects (over 150) for the longest period of time (4 years) of the ten year test cycle. The test results were captured in the State's internal audit. The process eventually ended due to a change in political party and the appointment of a new comptroller who wanted to return to the traditional, technical based project approach. It is interesting to note that the State has been unsuccessful in finding a process that duplicates the results of PIPS. Their current inability to identify or use performance information, and the inability to document the performance of construction projects supports the authors' hypothesis that the owner does not know the value of construction in the priced based environment. The analysis of performance in the Hawaii tests were done in several ways:

1. Of the 55 roofing clients, 100% stated that the PIPS contractors' performance was excellent, 100% stated that they preferred PIPS over low-bid award, and 96% were satisfied with the quality of work [19].

2. Out of 20 inspectors, 100% were satisfied with the PIPS work, 94% stated that the PIPS contractors were more willing to perform, and 95% stated that PIPS required less work for their staff [12].

3. A transaction cost analysis was performed on the roofing PIPS projects and low-bid projects. The analysis concluded that PIPS resulted in over 13% savings in the first cost in comparison to low bid [19]. This did not take into account the increase in quality.

4. A comparison of 96 PIPS roofing projects documented that [19]: 98% of the roofs were completed on time, the contractors produced approximately twice as much work per day, and stopped the practice of the State repairing its roofs during the warranty period.

A project run at the State of Georgia was very significant since it allowed a clear comparison of the first cost of running PIPS versus the cost of low-bid on the exact same project. The procurement of the $45M construction of an environmental wet laboratory was bid twice using both processes [8]. The first round of bids was done using the PIPS process. The bid was rejected due to the perceived high cost. It was later identified that the project was over-designed. The project was redesigned cutting $4.5M from the project. It was re-bid and awarded using the low-bid process. The project was still over budget ($46.6M) and completed at $48.8M and late by 50% of the initial construction time. The project was finally completed with over $2.2 Million in change orders and approximately one year behind schedule. The State of Georgia ran a second, similar project using PIPS. After awarding to the best performer, they proceeded to manage and control the contractor as though it was a low bid contract. The client was impressed with the contractor but discouraged by the bureaucratic control by the State.

The Dallas Independent School District (DISD) implemented PIPS on nine roofing projects. The implementation illustrated several key concepts, including:

1. Contractors that DISD thought were very low performing (due to past low-bid work), were capable of performing very highly under PIPS.

2. Contractors and manufacturers did not know the performance of their roofs.

3. Contractors and manufacturers immediately began responding to problems that DISD had been requesting to be fixed for over two years.

Table 3 summarizes the results of the PIPS implementation at DISD [10]. The projects were completed on time, and 13 percent under budget. Once again, the first costs were lower for higher performance than the low bid prices.

Table 3: Dallas Independent School District Project Results

NO	Criteria	Results
1	Total number of projects	9
2	Award Cost	$ 4,205,208
3	Budget	$ 4,824,357
4	Percent Under Budget	-13%
5	Percent satisfied with PIPS	100%
6	Percent of projects that finished on time	100%
7	Percent of project that finished within budget	100%
8	Average user rating of low bid (Owner scale rated 1-10, 10 is max)	1
9	Average user rating of PIPS (Owner scale rated 1-10, 10 is max)	10

4. Conclusion and Recommendation

The process based approach of PIPS, based upon the nearly 400 projects run using the performance based system, seems to be far more effective in minimizing construction performance issues than the project specific, low-bid approach. The success of the PIPS system shows that the Quadrant I, technically oriented, price based construction delivery process may be the primary cause of construction nonperformance. PIPS is fundamentally a Six Sigma application that defines the process, measures performance at the right time by the right party, automated the analysis process using fuzzy logic, forced continuous improvement without management and control, and minimized deviation through the process control (DMAIC.)

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What do Construction Workers do? Direct Observations in Housing Projects

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Abstract

Industrialization is currently seen as one of the most important developments in the Swedish construction. All large construction companies have initiated processes for more prefabrication, especially in housing. The reason is to develop more lean processes as a way to increase the productivity and the profitability. In order to learn more about how productive and efficient their production processes really are, the Swedish construction company Peab has introduced short studies on how the time of construction workers is used on site. Full-time observers follow different work activities in housing projects and register what randomly chosen workers do every second minute. The purpose of this paper is to illustrate one aspect on how efficient the production is, by presenting how construction workers' time is used on construction sites. The results from the case project, which is presented in this paper, indicate that less than 20% of the workers time is spent on direct value adding activities for specific activities and that approximately 20% of the time is direct waste of time.

Keywords: Industrialization, productivity, construction workers, housing, work sampling

1. Introduction

The Swedish construction industry is often viewed as conservative and producing buildings on high costs. At the same time, the general opinion is that the industry is under hard competition and that the profit margins are low. In order to improve the productivity, the major construction companies make significant investments in developing the production towards more industrialized processes, especially in housing where repetition is obvious.

Peab is, next Skanska and NCC, the largest Scandinavian company in the field of construction and civil engineering. The group runs construction and civil engineering operations primarily in Sweden, but also in Norway and Finland. The group net sales are SEK 20 billion with about 10,000 employees. In order to learn more about how productive and efficient their production processes really are, Peab has introduced short studies on how the time of construction workers is used on site. Another reason for collecting empirical data from the construction sites is that Peab several times has realized that most employees don't accept improvement programs or specific projects aimed for improving certain processes. Empirical evidence would be helpful to initiate discussions about how to improve the processes.

The aim of this paper is to increase practitioners as well as researchers attention on the potentials to increase the productivity in construction. It is done by presenting empirical data from one housing project. The more specific aim is to identify what construction workers do in housing projects, especially (a) to identify the efficiency defined as the percentage of time spent on direct value adding work, but also (b) to identify the waste defined as the percentage of time lost.

The results indicate that the time spent on adding direct value into the building is surprisingly low. There are strong arguments for paying more attention on developing more industrialized processes in order to increase the efficiency and reduce the waste.

2. Labour Productivity

Construction workers in Sweden are, in an international perspective, well educated. Most of them have studied nine-year compulsory school and then three-year upper secondary school education. The workers have an open and fairly independent role on site. It's common that they get fairly much information about the project and that they take some part in planning and work preparations. There is a trend to include more managerial roles into the workers' tasks. Since the 1980's, most construction workers are employed with conditional tenure.

Considering construction workers, there has been a number of work sampling studies in the U.S. for the last 30 years. Allmon et al. [1] summarize the trends in U.S construction labor productivity for the period 1970-1998. A research group at University of Texas at Austin studied 72 projects during this period. The annual direct work mean values for these projects varied from 41 to 61%. This is in line with Oglesby et al. [2], who predict that direct work falls within 40-60% in most construction projects.

The activities of workers in these studies are typically divided into three categories, according to Allmon et al. [1]. Direct work includes productivity actions, picking up tools at the area where the work is taking place, measurement on the area where the work is taking place, holding materials in place, inspecting for proper fit, putting on safety equipment, and all cleanup. Supportive work includes supervision, planning or instruction, all travel, carrying or handling materials or tools, and walking empty-handed to get materials or tools. Delay includes waiting for another trade to finish work, standing, sitting or any non-action, personal time, and late starts or early quits. Inspired by popular literature and oral presentations about the Japanese car manufacturer Toyota, we believe that this structure is rather passive and must be developed further in order to strive for world-class productivity. Direct work should for example be divided in direct value adding work and indirect work.

Several authors discuss factors influencing the productivity. Allmon et al. [1] mention project uniqueness, technology, management, labor organization, real wage trends and construction training. Moselhi et al [3] study change orders impact on labor productivity. Ng et al. [4] take another approach and look at demotivating factors; rework, overcrowded work areas, crew interfacing, tool availability, inspection delays, material availability and foremen incompetence. According to Kaming et al. [5] bricklayers, carpenters and steel fixers in Nigeria rank lack of material, rework, absenteeism, interference and lack of tools as the major productivity problems.

3. Methodology

The approach we have chosen for the study, work sampling studies, could be criticized in several ways. Allmon et al [1] argues, for example, that work sampling only gives information about time spent on activities and therefore gives indirect information about productivity. However, they mean that direct work time does not necessarily correlate with unit rate productivity. The level of labor skill and the standard of equipment may for example influences the productivity without necessarily influence the volume of direct work. An advantage with the approach is that it is less controversial than other approaches such as output per time.

The study is limited to one housing project, which was used also for some other studies within Peab. Of that reason, the personnel on site were used to development work and various types of studies. However, an introductory discussion with the site managers and the construction workers were carried through in order to guarantee that they realized the aim with the study; to identify what the workers do as a consequence of the organization, the plans and the production systems, not how fast they work.

The data collection was performed as direct observations by one of the authors. Before the studies started he used a random table to systematically decide in which order the workers would be followed and for how many observations. During the observations he tried to stand and walk in such way that he influenced the work and the workers as little as possible. He experienced that they quickly accepted him as a part of a natural working situation.

The registrations were done exactly every second minute from 6.45 in the morning when the work started until 4.00 pm when the work finished. But if the work of some reasons began earlier in the morning or finished later in the afternoon he extended the observations to also include these periods.

Three building elements were chosen of practical reasons. These were studied during one week each during 2004.

The authors developed a code structure based on experiences from similar previous studies and on which activities were performed during the study, see Table 1. Every observation included six questions.

- Which date the observation was made, example yy-mm-dd.

- What time the observation was made, example hh-mm.

- Which construction worker to observ.

- Which building element the specific worker worked with. A detailed code structure was used.

- Which activity the specific worker performed. Six main groups of general activities were identified depending on if it was value adding work, preparations for value adding work or just lost time.

- Comments were made now and then in order to clarify what the workers did and also to note various reflections made during the study.

Microsoft Excel was used to analyze the data. A summary of the each week of study was presented for the workers followed by a discussion on what could be improved.

4. Results

4.1 Case: Area Folkparken

The case project is initiated and developed by Peab. The budget is SEK 64 million. The site is situated in Haninge, approximately 20 km south of Stockholm. The product is a house with external galleries and is designed to manage heavy traffic noise from one side. The gross floor area 5,159 m^2 and the gross building volume is 14,703 m^2. The project includes 82 tenant-owned flats with 1-2 rooms each. The building, which is divided in three parts with different numbers of storeys, has the form of an “S” in order to be experienced as more slender and better harmonize with the environment. The form of the building was one reason to that the distances on the site were quite long. The closest distance from the production site to the workers facilities was 70 m, to the site office 110 m, and to the stock of material 30 m. The distance between the north and south end of the building was 90 m. Peab’s site organization was in the beginning of the project one site manager, one site clerk, and one foreman.

Three elements of the building were studied:

- Load-bearing structure. The structure is in prefabricated concrete, which consists of a floor structure and load-bearing walls. The assembling of the structure was performed by six workers and supported by one manager.

- Roof. The roof is tin plated with low gradient. The roof trusses are wooden and prefabricated. The roof work, excluding tin plate, was done by Peab’s personnel. The number of workers varied from three to six. One manager supported the work.

- Exterial walls. The wall, which is not load-bearing, consists of a prefabricated wooden structure. It is internally covered by plaster and externally covered by mineral wool and plaster. The work was done by two to four workers and supported by one manager.

4.2 Results

In total, 4,979 observations were done during fifteen days of study, Table 1. However, the number of observations corresponds to almost 22 full working days, i.e. eight hours long days. The reason is that two teams of workers were studied in parallel for some days, and some working days were ten hours. Direct value adding work was on average less than 20% of the total time. Note that this group includes some corrections of defects. Indirect work, material handling and work planning is needed to be able to perform direct value adding work. These groups of activities corresponded to 45.4% of the workers time. 25.5% were spent on indirect work, which includes all kind of preparations in a few meters distance from the working spot. Indirect work included mainly handling of material and equipment, but also work with temporary constructions. 13.9% of the workers' time were spent on material handling, which includes transportation of material on the construction site. There are common that construction workers take part in the planning of the production on Swedish sites. In this case was 6.0% of the time spent on work planning. Waiting and unexploited time corresponded to as much as 33.4% of the workers' time. Almost 20% of the time was used to move between working spots and also moving before and after breaks.

Table 1: How construction workers use their time in load-bearing structure, roof and facade.

Activity / Element of building	*Load-bearing structure*	*Roof*	*Façade*	*All*
Number of observations	*2185*	*1843*	*951*	*4979*
10 Direct value adding work	**23.9**	**18.0**	**12.2**	**19.5**
- "New" production	21.2	16.0	10.7	17.3
- Correcting defects	2.6	1.6	1.5	2.0
- Prefabrication on site	0.0	0.4	0.0	0.2
20 Indirect work	**27.1**	**29.1**	**15.0**	**25.5**
- Studying drawings	0.5	0.5	0.1	0.4
- Discussing the work	1.6	2.9	1.2	2.0
- Handling construction material	4.8	7.9	2.1	5.4
- Handling equipment	8.8	5.8	4.3	6.8
- Measuring for prefabrication on site	2.0	6.8	1.5	3.7
- Cleaning on site	0.5	1.1	0.2	0.7
- Temporary constructions	8.6	4.1	5.7	6.4
- Other	0.3	0.0	0.0	0.1
30 Material handling	**11.8**	**13.1**	**20.2**	**13.9**
- Handling material	4.0	6.6	8.7	5.9
- Handling equipment	7.7	6.5	11.5	8.0
- Other	0.1	0.0	0.0	0.0
40 Work planning	**4.9**	**5.6**	**9.6**	**6.0**
- Work preparation	2.7	2.6	6.0	3.3
- Coordination	0.9	0.9	2.6	1.2
- Other	1.2	2.1	0.9	1.5
50 Waiting etc.	**23.2**	**18.1**	**32.2**	**23.0**
- Waiting because of lack of coordination	1.7	0.3	1.7	1.2
- Waiting because of lack of material	0.5	0.0	0.1	0.2
- Waiting because of lack of machine or equipment	1.0	0.1	3.6	1.1
- Waiting because of lack of work/instructions	1.7	0.9	4.6	2.0
- Waiting because other people were late	0.1	0.5	0.4	0.3
- Moving between working spots	16.1	15.5	18.2	16.3
- Other	1.9	0.9	3.7	1.8
60 Unexploited time	**6.3**	**15.1**	**10.7**	**10.4**
- Accidents, absence due to illness	0.0	0.0	0.0	0.0
- Moving in connection to breaks	3.8	2.8	3.8	3.4
- Too late start	0.5	1.5	0.7	0.9
- Too long break	0.0	0.0	2.0	0.4
- Too early finish	0.0	2.5	3.3	1.6
- Other	2.0	8.4	0.9	4.1
90 Other activities	**2.9**	**1.0**	**0.0**	**1.7**
Total	100.0	100.0	100.0	100.0

5. Discussion of Results

We found that the direct value adding work was 19.5% of the construction workers time in this case. However, 2.0% of their time was spent on corrections of defects. Of that reason, the direct value adding work would be 17.5% of the time. This is surprisingly low percentage compared to the American studies, which reported 40 to 60% [1,2]. On the other hand, in this case we have followed the definitions of value adding work fairly hard. For example, if the worker picked up nails from the floor exactly when the registration was made we registered losses, even if it only took a few seconds to do it.

Looking at these figures we could argue that the efficiency was very low in this case. But we could also take the discussion a few steps further in order to carry the matters to an extreme for the company. During the time of the study approximately 6% of the employed workers were on sick-leave. If we include these workers we could argue that the direct value adding work for the company's construction workers are 16.4%! In the next step we could include the managers, who supported the workers. For the three building elements, there was approximately 1.0 manager per 4.5 workers. If we also include the managers on site we could argue that the efficiency is as little as 13.4% of the total time spent on site, Table 2.

Table 2: Direct value adding work from three perspectives

Direct value adding work	*(% of total time)*
Construction workers on the site	17.5
All construction workers employed by the company	16.4
All construction workers employed by the company + supporting managers on site	13.4

The wasted time is at least 19.1%, Table 3. Then we include correction of defects, all waiting except moving between working spots, and all unexploited time. The major areas of waste were moving in connections to breaks, waiting because of lack of work or instructions and correcting defects. The volume of wasted time is significantly higher than what has been reported in defects studies [e.g. 6]. Still, the volume could be higher if we analyze the reasons for moving between working spots, which corresponded to 16.3% of the workers time. Some of the preparations, i.e. indirect work, material handling and work planning, could also be consequences of problems occurred.

Table 3: Activities performed by construction workers divided into direct value adding work, preparations, moving between working spots and waste.

Activity	*% of total time*
Direct value adding work, excluding corrections	17.5
Preparations	45.4
Moving between working spots	16.3
Waste	19.1
Other	1.7
All	100.0

A great number of studies claim that a typical day for managers in general and also for site managers include numerous interruptions and change of activities [e.g. 6,7]. This study indicates that also construction workers seem to have very divided days. Figure 1 shows a typical eight-hour day at the site for a construction worker, excluding breaks for coffee and lunch. In this case the worker have changed activity at least 156 times during the day.

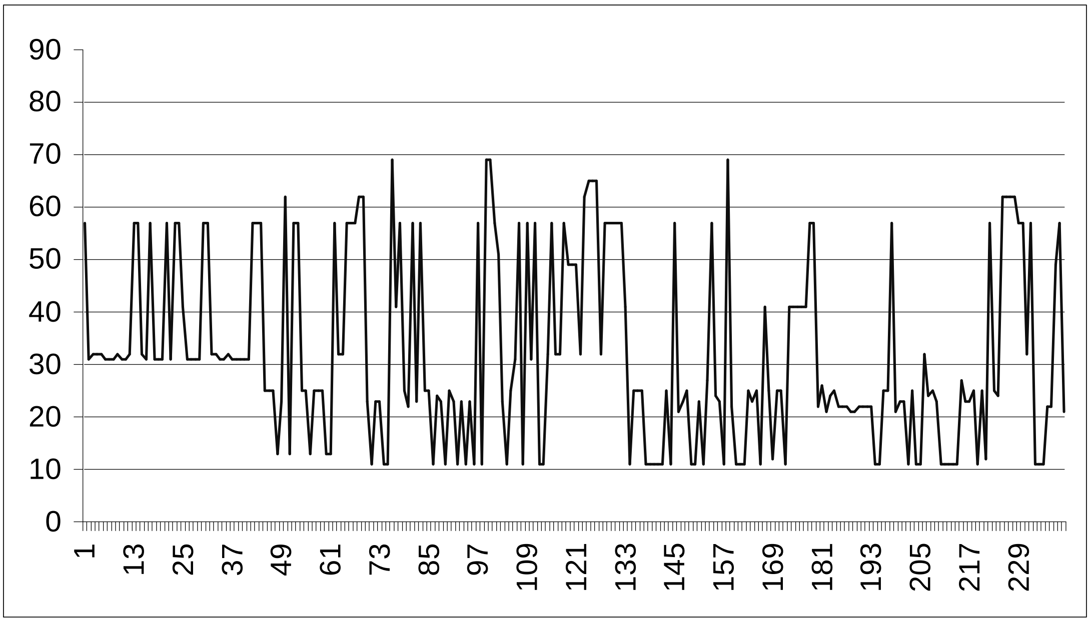

Figure 1: A typical eight-hour day at the site for a construction worker. The horizontal scale presents the number of minutes from start. The vertical scale presents the code for activities (see Table 1).

6. Conclusions and Recommendations

The aim of this paper is to identify how construction workers' time is used on construction sites, by making direct observations on site. The results form a strong argument for managers to pay far more attention on production processes than what is common today.

We have found that the efficiency is surprisingly low. Less than 20% of the workers time is spent on direct value adding activities. The obvious wasted time is approximately 20%, but will probably increase if we look closer at the indirect work and the handling of material and equipment. The typical day at work is divided and includes many different activities. The case considers a single housing project. However, the personnel within the project perceive it as quite normal. The results presented here should of that reason be considered as a typical example. There is a risk that the observer has influenced the team during the studies. We believe, however, that this influence is minimal. The main reason is that the study has been for such a long time that the individuals get used to people around.

The definitions of what is direct value adding activity, indirect work etc, has been quite hard in order to get as true picture as possible. We have experienced that practitioners tend to perceive indirect work and material handling as value adding. With influences from popular literature and a number of oral presentations about companies with more industrialized processes, especially Toyota, we have, however, decided to adhere to our original definitions.

The results indicate that further empirical data is needed in this area, as well as further analysis of the data, in order to better understand how much is wasted time, what kind of waste it is and what waste can be reduced or eliminated with existing production system as well as with other production systems.

The results have been an alarm for Peab. They have decided to also in future projects use the tool they have developed for work sampling studies about what construction workers really do. The approach is to make observations for a week and then analyze the data and go back to the site and discuss the results with the workers. On project level, the aim is to get the workers aware of the current situation and to get them create ideas of how to improve the situation. On firm level, the aim is to learn more about existing waste and how it can reduced.

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Variable Labor Productivity Unit Rate: Evaluation by Professionals

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Abstract

To forecast labor productivity indexes is a very important task to be performed, by the construction managers, in order to compose reliable building construction budgets and schedules. To do so, the main information sources have been the estimating manuals. These type of manuals are normally available in several countries, both developed and developing ones. The data, in such manuals, usually represent mean values for regional contractors performance. Although very easy to use, this approach, in the opinion of the authors, cannot be considered appropriate to the present context of Construction; the very competitive environment demands more accurate indexes to support managers' decisions.

Some recently developed researches, in Brazil, demonstrate the importance of considering a range of values to represent labor productivity unit rates instead of adopting a mean value for a broad scope of situations. The choice of a value from the proposed range would be based on the job's features.

Keywords: Labor productivity, productivity forecast, formwork, estimating manuals.

1. Introduction

The construction companies seldom measure the real productivity in their sites. So it is a current practice in Brazil to utilize productivity indexes gathered from estimating manuals to make budgets and schedules (Figure 1 shows the steps of a traditional budgeting process). These budgets and schedules are based on the physical resources consumption, which is composed by the labor, material and equipment consumption. This paper focus on labor consumption forecast for formwork job. Labor is the physical resource more difficult to manage and which demand have the highest variability. On the other hand, formwork is a labor-intensive task and often represents an event in the critical step of the project [1].

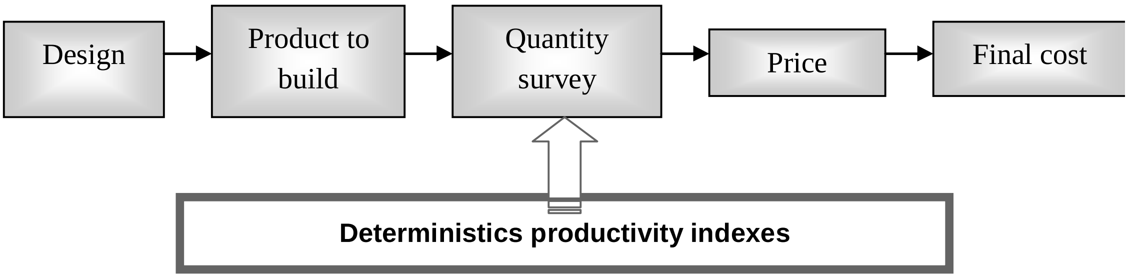

Figure 1: Traditional budgeting process

Two of the more important Brazilian estimating manuals, TCPO 2000 [2] and SBC [3], consider deterministic productivity indexes, as showed by the example in the Table 1.

Table 1: Productivity values formwork job taken from the main Brazilian estimating manuals for

Unit Rate (UR)	TCPO 2000	SBC		
	For whole formwork job	*For slabs*	*For beams*	*For columns*
Carpenter	1,35 Mh/m²	0,928 Wh/m²	1,268 Wh/m²	1,361 Wh/m²
Helper	1,35 Wh/m²	1,443 Wh/m²	1,773 Wh/m²	1,907 Wh/m²

*Wh/m² - Workhour per square meter of formwork

Authors as [4], do not indicate deterministic values on productivity forecasting. [5] emphasize that the simplicity on using deterministic approaches can be associate to a lost of precision on predicted productivities. [6] say that the costumers are not satisfied with the manuals values once they do not expose the job contend and context involved.

The high variability on productivity figures find representative of Brazilian building sites - that can reach 100%, according [7] e [8] - associated with the habit of using deterministic values and with an environment highly competitive generate a big insecurity on construction companies to forecast production costs. So, this paper intends to explore ideas linked to improve productivity forecasts to help the decision makers in the construction companies.

2. New Approaches to Forecast Productivity in Use in Brazil

The new approaches to forecast productivity discussed in this paper are based in the models prescribed on the literature (mainly on the Factors Model [9]) and on a productivity data base that have been collected since 1996 by the researches of the Department of Construction of University of São Paulo. The researches have been working on several different ways to of organizing productivity data to help the forecasting process. This paper discusses two of them: parametric equations developed by means of regression analysis and productivity range values associated to a list of factors that influence them.

The use of parametric equations was presented on [1]. Other research, as [11], added confidence to the statistical analysis. This paper deals with more recent parametric equations, as showed in 2.1 and productivity ranges on 2.2.

2.1 Parametric Equations

The unit rate for column, beam, slab and stair can be calculated by the following expression:

- ***bUR forecast - column***

$$bUR_{column} = 1.885 + 0.131BLE - (4.67SAR + 0.274BPL + 0.11TIE + 0.27LTI) + STR_{column} \quad (1)$$

Where:
UR = Productivity Unit Rate
bUR = Baseline for the skilled team
BLE = 0 when column leveling is based on each panel leveling; and =1 when column leveling is based on template leveling;
SAR: median cross-section area (in m^2);
BPL = 1 when column plumbing is based on studs plumbing; and =0 when column plumbing is based on whole panel plumbing;
TIE = 0 for removable ties; and = 1 for incorporated ties;
LTI = 1 for predominantly external ties; = 0 for predominantly internal ties;
STRcolumn = part of bUR referring to the column forms stripping. The proposed values for "STR" vary as showed by Table 2. One should choose higher whenever expects more difficulties in stripping the panels.

Table 2– "STRcolum" values variation range.

Minimum (wh/m^2)	Median (wh/m^2)	Maximum (wh/m^2)
0.13	0.14	0.30

- ***bUR forecast - beam***

The unit rate can be calculated by the following expression:

$$bUR_{beam} = 2.43 - 0.558BL + 0.267TU + STR_{beam} \quad (2)$$

Where:
BL = median beams length;
TU = 0 for when no tie is used; and = 1 for ties utilization;
STRbeam = part of bUR referring to disassemble beam forms. The proposed values for "STR" vary as showed by Table 2. One should choose higher whenever expects more difficulties in stripping the panels. The proposed values for "STR" vary as showed by Table 3. One should choose higher whenever expects more difficulties in stripping the panels.

Table 3– "STRbeam" values variation range.

Minimum (wh/m^2)	Median (wh/m^2)	Maximum (wh/m^2)
0.10	1.18	2.60

- ***bUR forecast - slab***

Floor structures with close slabs and beams raise difficulties in pulling down the formwork, inducing poor productivities (higher UR's). Table 4 presents some bUR values for slab formwork in conventional structures, where slabs rely on beams, and in plain slab structures, where slabs rely directly on columns.

Table 4 – bURslab values variation range.

Floors	**bUR_{slab}** (wh/m^2)	
Conventional structure (slabs with beams)	Minimum	0.40
	Maximum	0.96
	Median	0.69
Plain slab	Median	0.33

- ***bUR forecast – stairs***

bUR_{stairs} forecast can be based on the Table 5 information.

Table 5 – bURstair values variation range.

Stairs formwork	**bUR_{stair}** (wh/m^2)	
During the floor production	Minimum	1.78
	Maximum	2.64
	Median	1.93
After the floor production	Median	1.00

- ***bUR forecast – whole structure***

The $bUR_{whole\ structure}$ is calculated by the expression 3:

$$bUR = \frac{(bUR_{column} xA_{column} + bUR_{beam} xA_{beam} + bUR_{slab} xA_{slab} + bUR_{stair} xA_{stair})}{A_{column} + A_{beam} + A_{slab} + A_{stair}} \qquad (3)$$

Where:

bUR= baseline for the skilled team

A= area (m^2 of structure).

2.2 Productivity Range

Labor productivity figures are presented by mean of a “ruler”, having the minimum and maximum values of the database at the extremes and the medium value pointed out in the between. The “ruler” comes with the indication of the factors driving the expected rate towards right (unfavorable ones) or left (favorable ones), as shows the Figure 2.

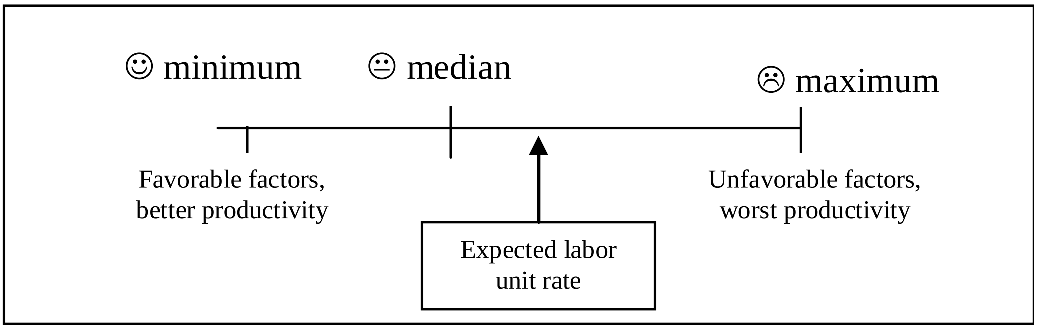

Figure 2: Concept of variable productivity range, Fonte: SOUZA et al.(2003)

In the Figures from 3 to 6 are presented labor productivity indexes range to carpenters of formwork job. The job envolves 4 tasks: column formwork (Figure 3), beam formwork (Figure 4), slab formwork (Figure 5) and stair formwork (Figure 6).

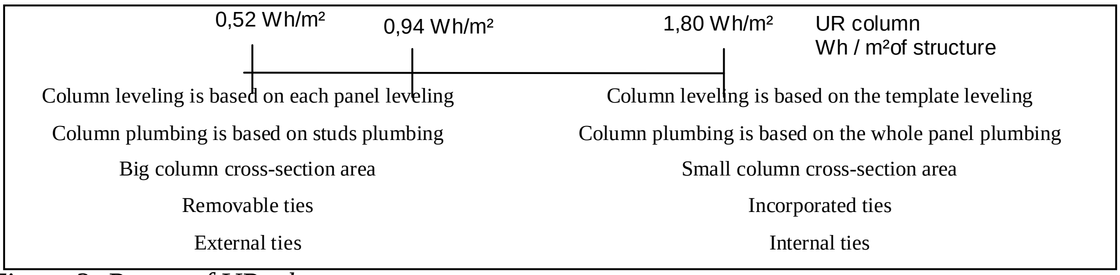

Figure 3: Range of URcolumn

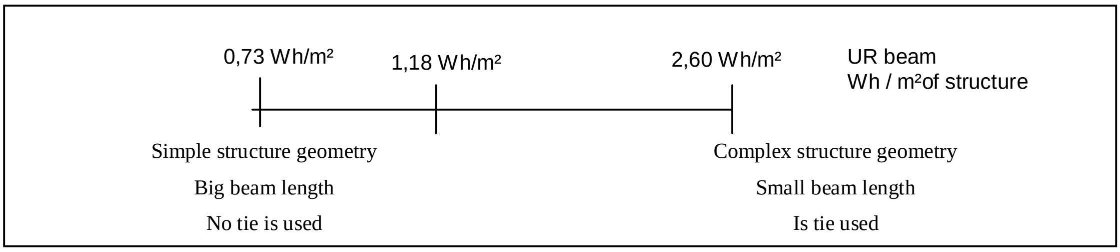

Figure 4: Range of URbeam

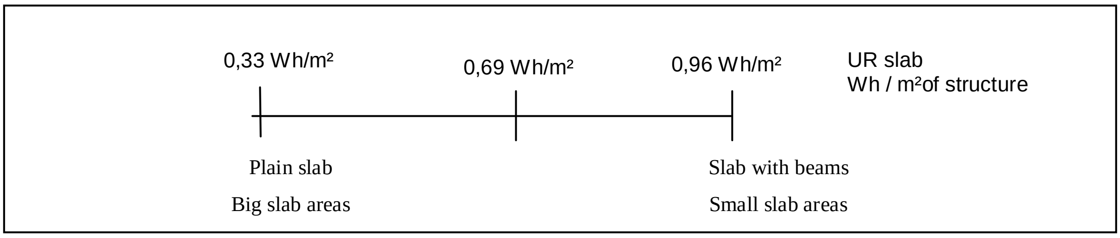

Figure 5: Range of URslab

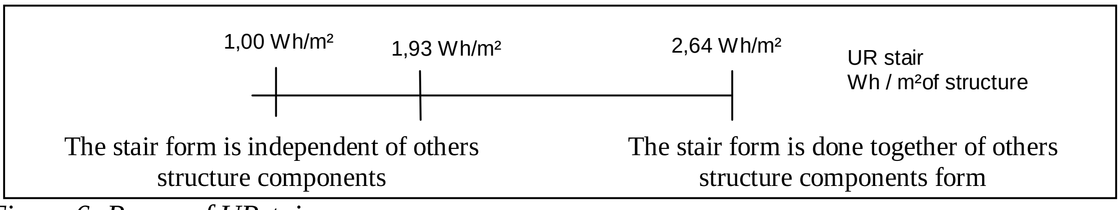

Figure 6: Range of URstair

Observe on Figure 3 that the median value is 80% superior to minimum and the maximum value is about 90% superior that median; this demonstrates the fault that we can do when the median value is chosen in situations in which one of the extremes were expected.

Any value within the range is accepted as possible value for productivity, although the expectations for the best or worst results involve other subjective factors.

In order to know the UR for all structure formwork, it should be done using the Equation 3. It will be necessary to chose on ranges what productivity better adequate to your build (minimum, median or maximum) and to know the dates of quantity extracted from projects.

3. Evaluating the Applicability of New Forecasting Approaches

The new approaches were tested following the steps of Figure 7.

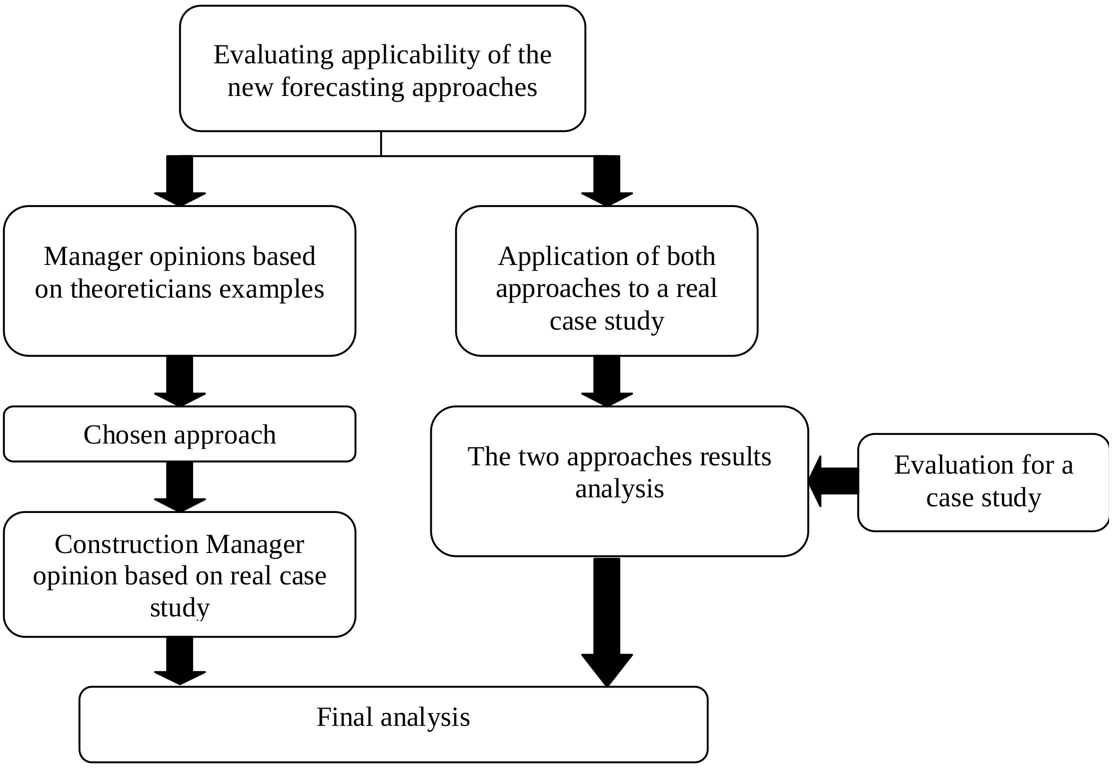

Figure 7: Methodology used to test the applicability of new forecasting approaches.

The test of applicability of two forecast approaches were has two ways:

a) First step - the approaches were submitted to construction managers to see what of them they feel more promising. These professionals were participating of a course about productivity concepts. They appreciate both approaches because they can have more dominion above the forecasts. Although they can apply the equations, they choose the ranges because they feel more comfortable on using it. After that, the ranges were presented to a construction manager that have never been in contact with productivity concepts or forecast. It was observed that he not feel secure as well in relation to factors relevancy as to analyze the productivity separately per components (column, beam, slab and stair). The manager have the feeling about total productivity that is necessary to get per type floor, this is due the labor contract model, which considers a fixed price per floor.

b) Second step – the authors did a forecast to a real build (that one in which the manager was questioned in the first step) utilizing as the range as the equation.

Productivity Range Forecast

It was chosen the follow values for the productivity:

- URcolumn: 0,94 Wh/m² (median value)
- URbeam: 0,73Wh/m² (minimum value)
- URslab: 0,69 Wh/m² (median value)
- URstair: 2,64 Wh/m² (maximum value)

The build had more favorable factors than unfavorable, however, to get more security on forecast, the median was chosen to column and slab. Only in the case of stair that the worst situation was chosen to be coherent with the factor, that was unfavorable. Based in these values and on survey of project quantities, applied on Equation 3, it were obtained the productivity forecast (0,80 Wh/m²).

Parametric Equation Forecast

It was given heights to the characteristics of build as indicated on 2.1 heading. The heights are presented on 3rd column on Table 6. Utilizing these heights into the Equations 1 and 2 plus the values chosen on Table 4 and 5, referent to structure components, it were obtained the results for column, beam slab and stair, which are presented on column 4th. These values were applied on Equation 3 to get the total productivity for whole structure, whose the result is presented on 7th column. The 5th column present the values chosen in the productivity range approach. The Table 6 shows yet, the Brazilian estimating manuals (SBC e TCPO 2000) values, on columns 6, 9 and 10.

In order to know the real productivity involved on formwork job in the floor, it were collected the quantity of hours worked for de formwork crew, which were composed only by carpenters (583 Wh/type floor; UR = 0,84 Wh/m²). This value is presented on 11th column on Table 6.

Table 6– Productivity dates for the real build.

Structure component	Build characteristics		Forecasted UR for the structure components (Wh/m^2)			Forecasted total UR (Wh/m^2)				Real UR (Wh/m^2)
			Equation	Range	SBC	Equation	Range	SBC	Tcpo 2000	
Column (200,5 m^2)	BLE	0	1,16	0,94	1,36	0,79	0,80	1,13	1,35	0,84
	SAR	0,12								
	BPL	1								
	TIE	0								
	LTI	0								
	STR	0,14								
Beam (153,3 m^2)	BL	3.81	0,40	0,73	1,27					
	TU	0								
	STR	0,10								
Laje (328,5 m^2)			0,69 (mediana)	0,69	0,93					
Escada (9 m^2)			1,93 (mediana)	2,64	0,93					
1st	*2nd*	*3rd*	*4th*	*5th*	*6th*	*7th*	*8th*	*9th*	*10th*	*11th*

Observes, therefore, that the forecasted productivity values obtained as for the equation as for the range (about 0,80 Wh/m^2) got a great forecast, because they are near to the real productivity (0,84 Wh/m^2) reached by the crew on the site building, while the estimate manual values are more distant to real productivity.

4. Final Considerations

The research with construction manager opinions not shows resistance on using of range. On the other hand, the position of construction manager interviewed presented critical, probably justified by the lost of training or sensitization about the subject and due to a form of labor contraction.

In the results analysis, although of, theoretically, the range presents a minor precision on forecast, because is a simplification on equations, it provides to a bigger easiness of application and the value gotten in this in case were satisfactory due to be near to the really it happened in the site build. On the other hand, the range eliminates some cited problems related to the traditional position (only presenting the average value).

Recently, one of the most important Brazilian estimating manuals included, beyond the traditional approach, the alternative approach of productivity ranges. The responsible believes that it can provide a better understanding for both, construction managers and designers, about the factors that influence productivity labor.

Once providing better understanding of labor productivity, the authors believe the “productivity range approach” can help improving cost and schedule forecasting in the Construction Industry.

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Evidence-based Improvement on the Royal Bank of Scotland, Gogarburn Construction Project

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Abstract

Numerous independent studies have shown that there is significant room for improvement on construction sites, particularly in relation to productivity, quality, health and safety, and innovation. At the new Royal Bank of Scotland (RBS) headquarters in Edinburgh, the client and the construction management team set out to produce a construction project that would be considered an example of best practice in the above categories, and create a stimulating and rewarding working environment for the whole construction team. BSRIA, an independent construction consultancy, helped achieve these objectives by delivering comprehensive and interactive training, monitoring and analysing key activities of the construction process, and compiling an evolving and evidence-based lessons-learned database for feeding back valuable knowledge into the project. The outcome was a construction project that has generated construction cost savings of 9.33% and a construction time reduction of 33.3% when compared to projects performing at conventional UK construction industry levels. This success was complemented by an outstanding health and safety record.

Keywords: Costs, Health and Safety, Performance, Productivity, Site Management

1. Introduction

1.1 The Construction Industry

The construction industry is the largest industrial cluster in the world. In the European Union (EU-15) construction accounts for an annual turnover of € 955 billion[1] and direct employment of 11.8 million people[2], or 11% of the total gross domestic product (GDP)[1,3] and 10.4% of all employment[2], respectively.

In addition to its importance as an industrial sector, the construction industry profoundly affects the overheads of all other industrial, commercial, educational, healthcare, recreational, communication and transport activities and makes a huge contribution to the quality of professional and private life across the world. It is evident, therefore, that business performance and the daily lives of the world's population can be improved with better health and safety, quality, environmental, social and productivity performance within the construction industry.

Although the construction industry does produce some very accomplished work, independent research (and various performance statistics) conclusively shows that there is significant room for improvement in project performance. Some of these areas for improvement are summarised below:

- Over the last ten years, BSRIA has conducted detailed research into site processes and construction productivity in some EU countries and in North America. The research has shown that approximately 50% of all site labour resource is wasted due to a combination of delays and variability in installation performance [4].

- In the UK, widely-used Key Performance Indicator (KPI) data showed that, in 2004, only 60% of UK construction projects were delivered on time, only 49% of UK construction projects were delivered on budget, and only 68% of UK construction projects scored 8/10 for defects at handover [5].

- Health and Safety Executive statistics for 2004 reveal that there were 4,001 major injuries and 8,162 over-three-day injuries on UK construction sites [6]. Seventy people were killed on UK construction projects in 2004 (30% of all worker fatalities occurred in the construction industry), which is equivalent to a rate of 3.55 deaths per 100,000 workers [6].

- Recent statistical data has indicated that average worker fatality rates for EU-15 countries are approximately 1.6 times higher than the UK figures [7]. In addition, the deaths-per-100,000 workers rate for construction in the USA is 11.4, which is more than triple the UK rate [8].

1.2 The RBS Gogarburn Construction Project

The RBS Gogarburn project involves the construction of a new worldwide headquarters for the Royal Bank of Scotland (RBS) in Edinburgh, Scotland. It has been designed to accommodate 3,250 people, with parking for 1,650 cars. The main part of the project comprises the construction of seven, three-storey office buildings and a 500-seat staff restaurant. These are linked by a 300 metre-long enclosed street, which contains assorted retail outlets and informal social spaces. A basement runs the full length of the development. It provides parking for cars and bays for bicycles, and contains storage, kitchen, mailroom and plantroom areas. In total, the main development, shown in Figure 1 below, extends to around 65,300m^2.

Figure 1: The main building at RBS Gogarburn

The site also features separate conference, nursery, leisure and sport facilities on site, which account for an additional 8,000m^2 of floor space to the project.

The total development budget for the project is £335 million. The construction costs are £229 million, of which around 10.5% has been spent on site organisation and 12.1% has been spent on preliminaries. Groundworks commenced in November 2002 and practical completion is scheduled in February 2005, creating a construction programme of approximately 27 months.

In line with the high ambitions for a headquarters project, the project team was also looking to create a construction project that demonstrated best practice in productivity, quality, and health and safety performance.

2. Delivering Performance Improvement at RBS Gogarburn

At RBS Gogarburn, the project team acknowledged that the creation of a stable, highly productive, safe and quality-focused environment would require an investment in both the development of the people who would work on the project, and in an initiative that employed evidence as a key mechanism for delivering performance improvement. BSRIA was invited by the project management company Mace and the client Royal Bank of Scotland to assist with the delivery of these two elements.

2.1 The “Moving Forward” Training Course

A key objective of the RBS Gogarburn project team was to create an effective and efficient workforce capable of safely delivering best practice levels of construction site productivity and an excellent finished product. In order to achieve this objective, the traditional, high quality building skills that the workforce possessed, needed to be complemented with improved competence in areas such as work preparation, meeting the needs of others, housekeeping, innovative ways of working and learning from experience.

In order to embed these new areas of competence in the project workforce, BSRIA designed, in close collaboration with the rest of the project team, a five-module, half-day, interactive, site-based training course called: “Moving Forward”. A colour, pocket-sized project handbook contained key project health and safety information and a two-page summary of each course module, together with tear-out pages featuring work preparation checklists and feedback forms that could be used by the project team.

The five, 25-minute modules were designed for delivery to everyone working on the project, from director through to apprentice and from architect through to scaffold erector. The content of the five course modules is summarised below.

- Module 1: Knowledge and Learning – *Outlined the key objectives of the project team, provided an overview of a simple review and improvement methodology, highlighted the role of the individual in making improvement happen and showed examples of where evidence-based review and improvement had been successful.*
- Module 2: The Changing Construction Site – *Contrasted the relatively unchanged, 5,000 year-old, construction methodology based upon lots of people taking lots of time to put lots of components together on site, with industries that have introduced paradigm shifts in their production processes. Introduced the concept of the modern construction process, which blends the best of traditional practices with new products and innovative ways of working. Provided examples of construction project teams that have made this change*
- Module 3: The Working Day – *Examined how the build process on site is typically composed, together with the inputs, resources and outputs that are required for successful task delivery. Showed how a typical working day is composed through the concept of productive and non-productive time.*
- Module 4: Work Area Control – *Introduced 14 characteristics of work area control, which together enable the workforce to build high quality products in a safe and highly productive manner.*
- Module 5: Tools you can use – *Reviewed the key elements of the four preceding modules in conjunction with the accompanying project handbook. Provided an*

overview of the continuous improvement activities taking place on the project, together with the lessons-learned database in operation on the project.

2.2 Evidence-based Review and Improvement

Clear evidence in the form of performance statistics and independently-configured lessons-learned were selected as key drivers for the continuous improvement process at RBS Gogarburn. In order to collect this evidence, BSRIA conducted detailed monitoring exercises on activities that were either principal consumers of time and cost, or that dominated the critical path of project delivery.

A crucial component of the activity monitoring was the measurement of what percentage of the working day was lost to delays across all key work packages. BSRIA used its 10 years of expertise in this field to pre-define the 14 delay types employed in this process.

In conjunction with this performance measurement, good practice or areas for improvement were identified during the monitoring activity, and a process of root-cause analysis was undertaken to identify the causal reasons and appropriate corrective actions. In addition to conventional written representation of this information, digital video clips and digital photographs were also extensively employed.

The evidence produced by the above activities was fed into a wide range of performance improvement mechanisms, such as a single-page feedback forms with embedded charts or photographs, multimedia de-brief sessions for specific elements of the project team, input to project meetings, and content for plasma screens and notice boards located around the site. In addition, all the evidence produced was stored in a lessons-learned database located on the project intranet, which was structured by work package and by file type.

3. Results

3.1 Knowledge and Learning

During a 21-month period, 976 people from 85 different companies have attended the BSRIA "Moving Forward" training course. This is the largest initiative of this kind ever undertaken on a UK construction project.

A project lessons-learned database, structured according the work package descriptions already in use on the project, has been populated with the following evidence:

- 221 single-page, colour feedback forms on a diverse range of issues, such as site logistics, interface details, housekeeping, installation productivity, delays, health and safety and quality management
- 407 video clips of key activities on site
- 2,220 high resolution photographs that capture the construction process and show key project details

All the above files have been named using a standard protocol based upon the use of a primary and secondary keyword, the work package number and name to which it relates, a date and a identifier for the file type. *E.g. Protection-curtain wall-3200-external cladding-10 Nov 04-V.* This approach has facilitated easy storage and retrieval of the evidence.

3.2 Cost and Time Performance

At the time of writing of this report, the RBS Gogarburn project is 96% complete and one month away from practical completion. The project will be delivered below the original budget and four weeks ahead of the original completion date.

A key contributory factor to this impressive cost and time performance has been that the project team has managed to increase the amount of productive time during each working day, when compared to conventional UK performance. Over a 21-month study period, each person working within the observed construction teams at RBS Gogarburn lost an average of 20% of each working day to delays. Although there is room for improvement in this level of performance, this figure is significantly lower than the average UK construction industry benchmark of 40%, which was established by BSRIA during its detailed research between 1994 and 2002 [4,10]

Site personnel costs on the RBS Gogarburn project were an average of 28% of the total construction costs. This figure corresponds closely with other reference sources that have examined the configuration of costs on construction projects [9].

The effect that the improvements in productive time have had on time and cost certainty on the project is illustrated in Figure 2 and Figure 3 below. The analysis shows that if the project had experienced delays at conventional UK construction industry levels of 40% of the working day:

- The construction cost would have increased from £229 million to £250.4 million, or by 9.33%
- The construction programme would have increased from 27 months to 36 months, or by 33.3%

Actual construction cost performance on the RBS Gogarburn project with productive time equal to 80% of the working day	
Construction cost	**£229**
Non-labour cost at 72% of the construction cost	£164.9
Labour cost at 28% of the construction cost	£64.1
The amount of the labour cost converted into productive time (*80% of the working day)* This figure is therefore the cost of the actual manpower required to build the project.	£51.3
The amount of the labour cost consumed by delays (*20% of the working day)* This figure is represents the cost of the manpower that was paid for, but which did not contribute to the building of the project.	£12.8

Theoretical construction cost performance on the RBS Gogarburn project with productive time equal to 60% of the working day	
The cost of the manpower, or productive time, required to build the project. *(This figure is the same as in the table above because the quantity of built product is the same)*	£51.3
The amount of the labour cost consumed by delays*. (40% of the working day)* This figure is represents the cost of the manpower that was paid for, but which did not contribute to the building of the project. *(The cost of this element is significantly higher than the corresponding figure in the above table. This is because the productive time component of £51.3 in this table represents only 60% of the working day, as opposed to 80% of the working day in the calculation used in the above table)*	£34.2
Labour cost required for the delivery of the project.	£85.5
Non-labour cost required for the delivery of the project. *(This figure is the same as in the table above because the quantity of built product is the same)*	£164.9
Construction cost	**£250.4**

Figure 2: An analysis of construction cost performance on the RBS Gogarburn project (All figures are in £ millions)

Actual construction time performance on the RBS Gogarburn project with productive time equal to 80% of the working day	
Construction programme duration	**27 months**
The amount of the construction programme converted into productive time (*80% of the working day)* This figure represents the actual productive time required to build the project.	21.6 months
The amount of the construction programme consumed by delays (*20% of the working day)*	5.4 months

Theoretical construction time performance on the RBS Gogarburn project with productive time equal to 60% of the working day	
The amount of the construction programme required to build the project. *(This figure is the same as in the table above because the quantity of built product is the same)*	21.6 months
The amount of the construction programme consumed by delays. *(This element is significantly higher than the corresponding figure in the above table. This is because the productive time component of 21.6 months in this table represents only 60% of the time required, as opposed to 80% of the time required in the calculation used in the above table)*	14.4 months
Construction programme duration	**36 months**

Figure 3: An analysis of construction time performance on the RBS Gogarburn project

3.3 Health and Safety

Over five million man-hours have been worked on the RBS Gogarburn project since construction activity commenced. Three reportable injuries have occurred during this period. This level of health and safety performance is more than ten times better than the current average level of performance for the UK construction industry [6,11].

The level of health and safety performance generated on the RBS Gogarburn construction project demonstrates that the combination of a well-trained, motivated and responsible workforce, excellent site organisation and the provision of appropriate plant, tools and equipment does generate a reduced incidence rate of reportable injuries.

The achievement of the project team was recognised in January 2005 when a film crew, commissioned by the Health and Safety Executive, interviewed 20 workers at the RBS Gogarburn construction project. These individuals were asked to provide feedback about working on a project where a great emphasis had been put on best practice health and safety performance. The edited version of the video was shown at the Construction Health and Safety Summit 2005 – a major conference on health and safety in construction held in London in February 2005, which was attended by senior executives and trade union officials from the construction industry, as well as senior representatives from UK governmental departments.

3.4 Quality

A study of the causes of defects recorded on the project prior to practical completion revealed that 54% of all defects on the project were attributable to outstanding works, 20% were attributable to the quality of workmanship, 13% were attributable to the precision workmanship, 12% were attributable to damage of finished work, and 1% was attributable to either material or functional faults.

A analysis of the time taken for the clearance of individual defects from the project management system employed on the project also highlighted that there was not enough commitment from the specialist trade contractors to providing dedicated teams who assumed responsibility for finishing the project in a defect-free manner.

The above evidence was fed back to the organisations working on the project and this helped the project focus on the key factors that were inhibiting the delivery of a defect-free project at handover to the client. Consequently, the project team has been able to work towards project completion in a much more controlled manner than normal UK construction projects that have not had this level of understanding.

4. Conclusions

- The global construction industry has significant room for improvement in its cost, time, quality, and health and safety performance.

- If properly trained and motivated, the construction workforce is capable of delivering improvements in cost, time, quality, health and safety performance. Site-based training of the workforce should be more widely adopted by construction project teams. It should focus on complementing workers' traditional technical skills with improved competence in work preparation, meeting the needs of others, housekeeping, innovative ways of working and learning from experience.

- Evidence-based review and improvement is an effective mechanism for improving performance on construction projects. This approach enables teams to identify, review and improve the things that really matter, and should be more widely adopted by construction project teams.

- Performance improvement on construction sites generates significant economic benefits for all parties involved. Improved working conditions also create considerable social benefits for the workforce.

- Performance improvement in the construction industry will generate benefits for all other industrial, commercial, educational, healthcare, recreational communication and transport businesses.

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Definition defects at handover: Some defects with no significant impact on the client

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Definition reportable injuries: In the UK, injuries during work activity are reportable to the HSE when they are fatal, major (e.g. fractures), or cause absence from work for more than three days

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Scientific Benchmarking of Building Projects – Model and Preliminary Result

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Abstract

The Norwegian construction industry needs a benchmarking tool suitable for both common and individual use. The R&D project "Productivity in Norwegian construction industry" uses a scientific method, the Data Envelopment Analysis (DEA), for this purpose. The challenge has been to identify and collect data and supplementary facts for the analysis. The study is carried out at the project level. The data collection tool, i. e. a questionnaire with guidelines, has been designed with focus on the project as a whole. Likewise, much effort must be put on identification of the most important parameters. The contractor's point of view is chosen and the sampling for the investigation must consist of fairly similar types of projects. A pilot study on the production of blocks of flats is carried out. The preliminary benchmarking result is suggestive and encourages the R&D project team in the commissioning of the pilot study and start of new investigations.

Keywords: Productivity analyses, efficiency analyses, benchmarking, statistics in construction, cost control

1. The R&D Project

1.1 Overview

Productivity in Norwegian construction industry is a five-year (October 2001- September 2006) research project with an estimated effort of 200 person-months. The main goal is to develop a tool for scientific benchmarking of building projects. The project is based on cooperation between two research environments; the Department of building process studies of NBI and the Frisch centre / Department of Economics at the University of Oslo. The economists support the project with know-how of applying benchmarking using the non-parametric, multivariate method for efficiency analysis referred to as DEA (Data envelopment analysis [2]). Further development of this method is a separate part of the project; see paper by Dag Fjeld Edvardsen, NBI [1].

1.2 Background

In the period 1995 – 2000 the Norwegian construction industry experienced a severe decline in productivity. Observing this in the context of similar figures for the average of all industries in Norway leaves an alarming impression. See figure 1.

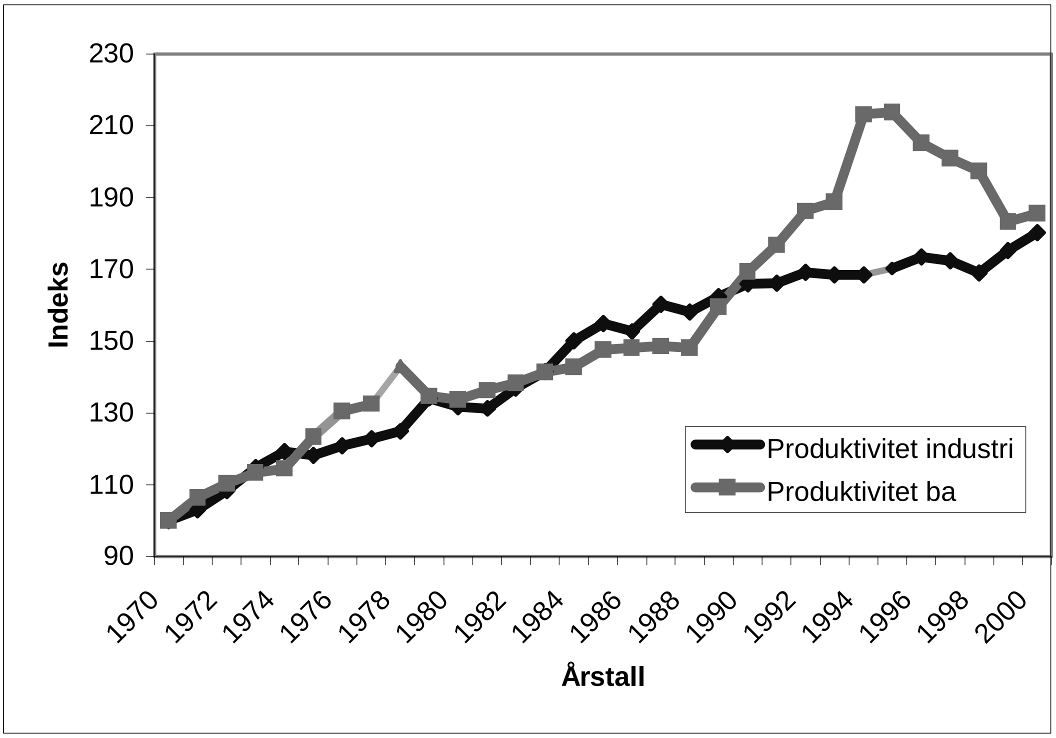

Figure 1: Development in labour productivity (grey) in construction industry vs. all industry (black) 1970-2000. Index 1970=100. Source: Norwegian national accounts

The dramatic (right) part of the curve has been given de-dramatizing explanations like

- the construction industry is very sensitive for change in business cycles

- the labor productivity figure, from national account, is not suitable as a basis for discussion of the productive efficiency in an industry like construction.

Nevertheless, the unpleasant development of productivity and the recognition of national account figures as non-suitable for productivity studies in construction industry, gave birth to the R&D project presented here.

1.3 Industrial Need

The construction industry is important for any industrialized nation. In most European countries it has a 5 – 15% share of the gross national product (GNP). The importance is strengthened by the fact that the construction industry has a strong impact on all other sectors in the economy.

To keep their "competitive edge", construction companies, as all other companies, has to establish and support their individual, continuously running improvement programs. The *ideal* concept for improvement work is an systematic, scientific approach, including productivity measurement and statistic analyses, as recommended in the ISO 9001:1994 Quality systems. In the Norwegian construction industry this is not very often observed. It is more usual, if there is any improvement program at all, that it is a "gut-feeling"-based approach with low attention to data and statistics.

Few productivity studies have been carried out in the past in the construction industry. The main experience is that data collection is difficult and that low quantity of data causes low quality of the results. Consequently the industry does not know much about itself through statistics. A few national account based studies indicate that the efficiency fluctuates with the business cycles. That is about all. There is a lack of knowledge about how to measure productivity/efficiency and how to identify influencing factors. The aim of the ongoing R&D project is to change this unsatisfying state of art.

2. Productivity and Efficiency in Construction Projects

2.1 Measuring Productivity

This paper gives a summary of the early phase work of the R&D project. The aim was (is) to develop a model for measuring productivity of building projects, on which a final benchmarking can be carried out. Productivity is defined as the ratio

$$\textbf{Productivity} = \frac{\textbf{Product} \text{ (e. g. figure(s) giving precise quantitative measures of the delivered product)}}{\textbf{Resources} \text{ (e. g. figure(s) giving precise quantitative measures of resources used)}}$$

In construction industry, the tradition has been – and still is – to pay the workers ("blue collars") based on *labour productivity* (piece work contracts). Between the worker's union(s) and the contractors' trade union federation(s) normative references are established for all types of operations in the construction process. For given parts of a project, e.g. the floor construction, one can calculate the labour productivity as:

$$\textbf{Productivity of floor production} = \frac{\textbf{Floor area} \text{ (f.ex. 1000 m}^2\text{)}}{\textbf{Hours} \text{ (f.ex. 500 hrs.)}}$$

For sub-contractors with floor constructions produced on-site as the main product, this number will be of high interest for every contract they carry out. (In the denser parts of Norway, such organizing/specializing of the building process is normal). Even for this type of company, the floor production differs from project to project. Span and thickness of the floor construction differs, and so does the specification of the concrete, the required finish, the number of block-outs, embeddings, etc.

When it comes to production of a complete building, the challenge of measuring productivity is increased: First of all, not all activities in the building process are as easy to single out as the production of floor slabs. Normally 10 – 30% of the tasks will be handled in other ways than through a piece work contract. Furthermore, most buildings are one-of-a-kind projects, making systemizing and use of productivity data resource consuming and difficult. With the increased number of sub-contractors in an ordinary project, the productivity data will be spread on different companies. Finally, the ability to produce a building with a minimum of resources (with highest possible efficiency), seems to depend on how much time is “leaking out” *between* all specified activities, different professions and/or contracts in the project.

Measuring productivity has different challenges. One of them is how to separate the productivity from the profit, see figure 2.

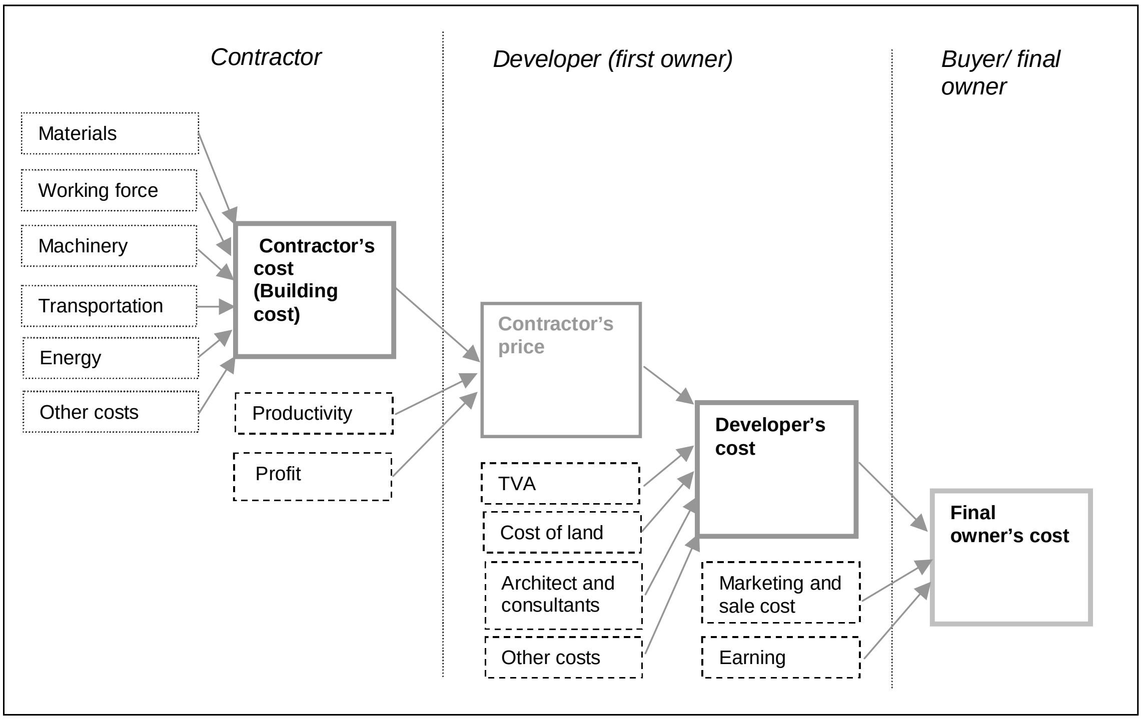

Figure 2: Building – the value chain. Source: Eurostat 1996

In figure 2, *productivity* is illustrated as an individual item, separate for the cost and the profit. In the contractors' books, the phenomena of productivity will show up as a part of the profit figure. If the productivity has been better than anticipated, this will become visible as a higher profit figure than calculated. If the productivity is lower than planned, the profit will become lower than calculated. (Other relations can also have a similar influence on profit. This makes the detection of "through productivity" even more difficult. - *The productivity box* in figure 2 can be read as an emphasizing of the fact that productivity is a specific aspect of the production that should be identified).

2.2 Comparing Productivity

From improvement point of view the productivity number has limited interest. The interesting part is to learn how well one producing unit is performing compared to other units, to it's own earlier performance(s) or to some normative number. When comparing productivity, each producing organization in a sample will come out with it's own "E-score" (the efficiency score), see figure 3.

$$E_n = \frac{P_n}{P_{Ref}}$$

Figure 3: Efficiency ("relatively productivity") for a unit (n) with reference to the unit (Ref)

The DEA method uses economic theory to rank a group of producing units from the most efficient one(s) (E-score 1.0) to the least efficient ones with scores from 1.0 and downwards. The main principle of the method is that each unit in the master sample is compared to the one(s) with highest E-score (1.0), i.e. the units that have demonstrated *best practice.* The theory is complex and can be studied in relevant literature, see for instance [2]. The basic condition for carrying out a proper benchmarking by this method is that the products are comparable ("Apples compared with apples"). Crucial is also that collected data are consistent and of satisfactory quality. Discussion of these aspects of the research process is presented in 3.1.

An interesting part of the early phase work was the discussion of details with respect to *point of view*, i.e. if we should establish our investigation with the owner's point of view or the contractor's point of view. The contractor's point of view was chosen, mostly because the fact that the word *productivity* in a historic perspective is connected to *physical production*. (See also figure 2, where the "productivity box" is connected to the contractor. On the other hand, the owners also conduct their business with different skill and success, and it would be of great interest to study the productivity based on the cost figures of the owner).

To reduce “market disturbances” we asked the contractors for their cost *without* profit. The fact that the contractors’ cost numbers contain the profit of their *sub-contractors* can produce “noise of second order”, but we regarded this as a minor problem.

Conclusion of the preparatory activities:

1) A tool for productivity measurement in the construction industry has to focus on *the project as a whole*.
2) The challenge is to identify the most important parameters for the nominator (product) and the denominator (resources) in the productivity formula, see above.
3) The resource data shall be collected from the *contractors’ project accounts*
4) The main sample must consist of fairly similar types of projects

2.3 The Pilot Study

To succeed with the modeling work, it was necessary to focus on one certain type of construction project. It was, for several reasons, natural to choose blocks of flats for the pilot study.

One of the benefits of DEA is the fact that the analysis is not dependent on a representative (large) number of items in the sampling [1]. Traditionally, a homogenous set of approximately one hundred items is regarded as satisfactory for a qualifying analysis. Based on this, we planned a data collection operation with the goal of getting 120 units, thus keeping the necessary number of qualified projects after excluding “bad data” items.

Blocks of flats-projects were defined as

- buildings with at least three floors
- buildings that can, but does not need to, have cellars (lower ground floor)
- projects that include common stair(s) and lift(s)
- buildings where the area of flats exceed 50% of total main function area. This means that part of the project can host other functions, like stores, institutional service function etc.
- projects that are one single block of flats or more than one (many)

Preferred type was defined as blocks with apartments of two, three, four or more rooms, principally planned for sale in the market. But other types, like studios, student housing, buildings with a share of social service department, were also accepted.

As many contractors as possible, situated all over Norway, should be invited to participate with information. Each reported project would have to be completed, physically and with respect to the project accounts.

A questionnaire was prepared to the collection of data and other project information. It was divided into four parts, one for each type of information, see figure 4.

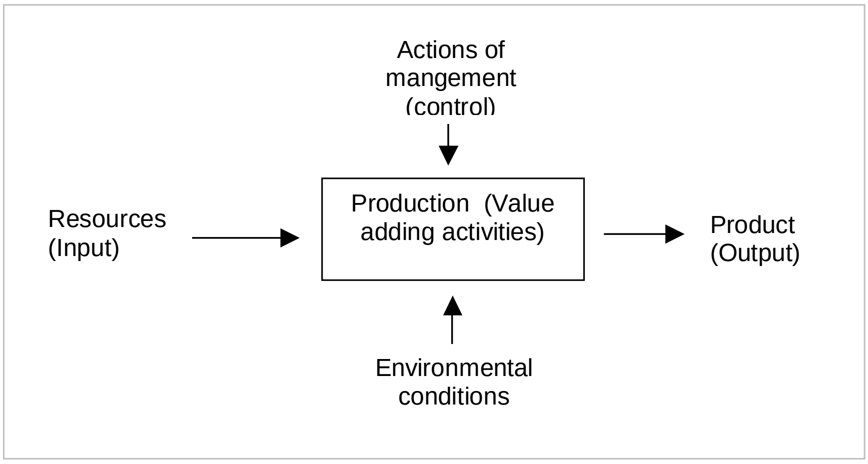

Figure 4: Efficiency analysis – the four main groups of information

The efficiency ranking of the group of building projects is based on calculations of data from the two groups Resources and Product See discussion of the productivity ratio in 2.1 (above). The other two groups of information are the *explanatory variables*, which are used in step two of the analysis, where regression technique is carried out to identify correlations between efficiency and the different variables. The Resources and Product parts of the questionnaire are commented in the following two chapters. The two parts covering explanatory variables are discussed (shortly) in 3.3. (An additional part asks for ID of the project and some rough characteristics. This firs page of the questionnaire is not given further comments in this paper).

The questionnaire is prepared for communication between the R&D project and each actual building project's manager. The ideal way of data collection, i.e. to invite the participants so enter the R&D project's homepage (www.byggforsk.no/productivity) and fill out the questionnaire, was abandoned after testing the probability of broad response this way. Conclusion was to open different ways of answering, giving each project manager the freedom to use the one preferred by him – or her. (The main sampling includes approx. 3 % female project mangers, unfortunately too few to test hypothesis "Efficiency and *female management*"). Approx. 40 % returned the questionnaire as attachment to e-mail. Another 30 % answered by post after having filled in information by pen. The last 30 % was also a paper copy, filled in by the R&D project representative during meetings with the building project manager that wished "1:1-information" before doing the answering job, which was estimated to take 3 – 6 hours. For more about data collection experience see section 3.1.

2.4 Resources

In productivity measurement theory [2] resources normally are grouped as follows:

Working time; f. ex. man hours. (B15 + B16 + B23 + B24)

Materials; raw materials and manufactured components for enclosure. (B22)

Energy; heating, enlightening, running of producing machinery, etc. (B13)

Capital; rent of machinery and equipment supporting the production) (B11)

To carry out the efficiency study, we needed these types of data for each building project. The Norwegian Standard NS 3453 *Project cost structure* (chart of account for building projects), includes all four of these resource groups. This gave input to the design of the part B of the questionnaire. See figure 5 and the numbering in brackets above. Unfortunately the NS 3453 structure does not correspond directly with the contractors' calculation sheets and charts of accounts. Each company has it's own structure, mainly following the construction process from ground work and concrete structure to technical installation and interior finishing work. (Curiously enough, the difference between the different charts of accounts is small. It seems mostly to be a result of habit and traditions. It should ease future data collection, if all companies and projects had taken the same charts of account into use).

As long as the contributors' charts of accounts were different, the R&D project was in a state of (strong) uncertainty regarding how good each project's information about use of resources could match any structure in the questionnaire. Consequently we designed the questionnaire to take care of both a "worst case" and "best case" responding situation.

Worst case: Low degree of detailing in many project accounts. The anticipation was that even if this would be the situation, all of the project managers most certainly would know the *B-40 figure* for his own project and give the R&D project this minimum of information necessary to feed the DEA model, see figure 4.

Best case: Highly detailed account in most every project. The expectation was that all cells in the break-down-column (Level 2) would be filled with the actual cost figure for each project, thus giving us high freedom to develop the optimal model.

B- Resources (Inputs)				

To get updated on the principles of this study, take a quick look at the first chapter of the Guidelines

		Level of information 1 Main figures (in 1000 NOK)	*Level of information 2* Brake down costs	*Level of information 3*
B-10	**Common costs (establ. + running the site).....**			
B-11	Rent of machinery, production tools etc.			
B-12	Waste; rent of containers, transportation etc.			
B-13	Cost of el. energy for running the site			
B-14	*Salary, production mangement/staff*			Number of workin hours
B-15	*Wages + worked houres, own empoyees*			
B16	*Cost of workers hired through personell support companies*			
B-17	Other costs (reg. establishing and running the site)			
B-20	**The building**			
B-21	Sub-contractors			
B-22	Costs of materials (for own producton)			Number of workin hours
B-23	*Wages + worked houres, own empoyees*			
B-24	*Cost of workers hired through personell support companies*			
B-25	Other costs (if any)			
B-30	**Technical installations……**			
B-31	HVAC			
B-32	Electricity			
B-33	Low voltage installations (Theleph., ….)			
B-34	Lifts			
B-35	Other installations (if any)			
B-40	**Acc. Cost of building, see Norw. Stand. 3453 …..**			
B-51	*Outdoor works (green surroundings, etc.)*			
B-50	*Acc. Cost of enterprise, see Norw. Stand. 3453 ……*			
B-61	*Costs of detailed planning (after general permission)*			
B-60	*Turn key cost", see Norw. Stand. 3453 ……*			

B-70	Check of the quality of the filling in:	Mark a positive answer (Yes) with a X
1	All figures are cost figures, i.e. NOT including our own gross margin and profit	
2	The figures are NOT including VTA	
		In 1000 NOK
3	B-40 includes following costs regarding non-conformancy work, either already paid out or expected to be paid during the "warranty period"	

Figure 5: Questionnaire – Part 2 Resources used in the building process

We also had a “Very best case”, which was all “man hours-cells” filled in with figures for each project (Level 3 in figure 5). This information would improve our platform even more, as we then would reduce the need for deflating the costs (index problem).

2.4 The Product

The most common way to quantify the product (the result of a building process) is by the gross floor area. Through this simplified way of quantifying the product, and with cost as quantification of the resources, the productivity factor of a project will be

$$\textbf{Productivity of floor production} = \frac{\textbf{Floor area} \text{ (f.ex. 1000 m}^2\text{)}}{\textbf{Hours} \text{ (f.ex. 500 hrs.)}}$$

In Norway this ratio is often used as an indicator of productivity or cost efficiency (Square meters/NOK - or more usual the inverse; NOK/square meter). As an indicator it might be suitable, at least among experienced builders. As measurement unit it is too rough, since important aspects of the product, like differences in standard ("quality"), important environmental conditions like ground, etc. is disregarded.

The great benefit of the DEA is the ability to take more than two aspects into consideration when measuring productivity. In short, the method, and the high computer capacity of today, gives us the opportunity to carry out numeric calculations of productivity with many independent variables, that is 4 - 8 when the data set consists of approx. one hundred items.

Part C in the questionnaire was designed in a similar way as shown in figure 5, though consisting of two A4 pages, due to the many aspects needed to define and quantify the actual product. Table 1 contains the factors asked for in the part C of the questionnaire.

Table 1: Product definition factors for blocks of flats

Quantifying factors for blocks of flats	Comments
1 The block(s) in general	
- number of blocks	
- number of floors (total, incl. basement(s))	
- number of basement(s)	
- number of lifts	
- number of indoor stairs/staircases	
- number of flats with open fireplaces	for gas or wood
2 The Block(s) – areas	
- gros area (BTA)	
- open air area (OPA)	galleries, balconies, terraces
- total areas of flats	(BOA and/or “BRA-Sale”)
- heated area for other main function than living	F. ex. stores at ground floor
- area for parking and tchn. func. in basement(s)	Data control question
3 Standard of construction (“qualities”)	
- standard of specified parts of the flats	7 different parts are quantified
- standard of the exterior and common areas	4 different parts are quantified
4 Non conformance to specification	
- degree of non-conformance at hand over	Degree of remarks in the protocols
- cost of repair during the guarantee period	In Norway this is 5 years by law
5 Energy for heating	
type of energy delivered	main source of heating
type of heating systems in the flats	main system of heating

3. Efficiency Analysis

3.1 The Data Set

During the period from June 2003 to January 2005 data from 138 completed blocks of flats projects were collected. The collecting process lasted longer than expected. Different circumstances can explain this, but it should be stressed that the R&D project is a model development project and not an ordinary collection of data for statistically processing in an existing tool.

The many projects were all built in the period 2000 – 2005. Based on the filtration criteria, see 2.3, nine projects were excluded, thus leaving an early main sampling of 129 projects. Suppliers were 37 contractors/ 65 profit centers (regional offices, departments) throughout Norway. The size of the projects varied from 7 mnok to 450 mnok with arithmetic middle of 77 mnok, respectively 6 to 618 dwelling units with arithmetic middle of 75 units.

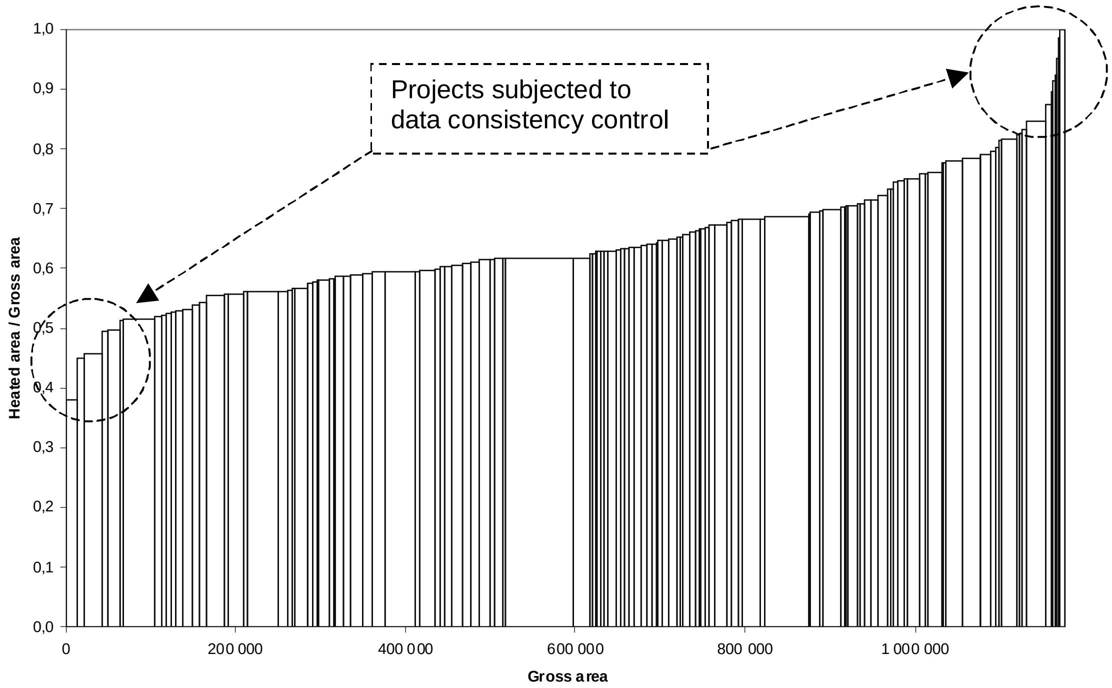

Figure 6: Example of data consistency control.

The quality of the present set of data differs, even if much effort has been put into control of data during the collecting phase. Checking the data set is still an ongoing activity. At the time of writing, 12 different data consistency controls have been carried out, and a similar number will follow. Figure 6 shows the ratio “Heated area”/Gross area. The “tails” (see dotted circles) of the diagram calls for special attention. The values (area numbers) behind the extreme low, respective high, columns are hopefully correct, but by controlling these once again we can discover miscopies, slips or errors or have even higher confidence to the data set.

3.2 Preliminary Efficiency Benchmarking Result

Based on the partly checked data set a preliminary result of the efficiency analysis can be presented, see Figure 7. The result is based on a DEA model with seven variables, operated by project colleague Dag Fjeld Edvardsen of NBI.

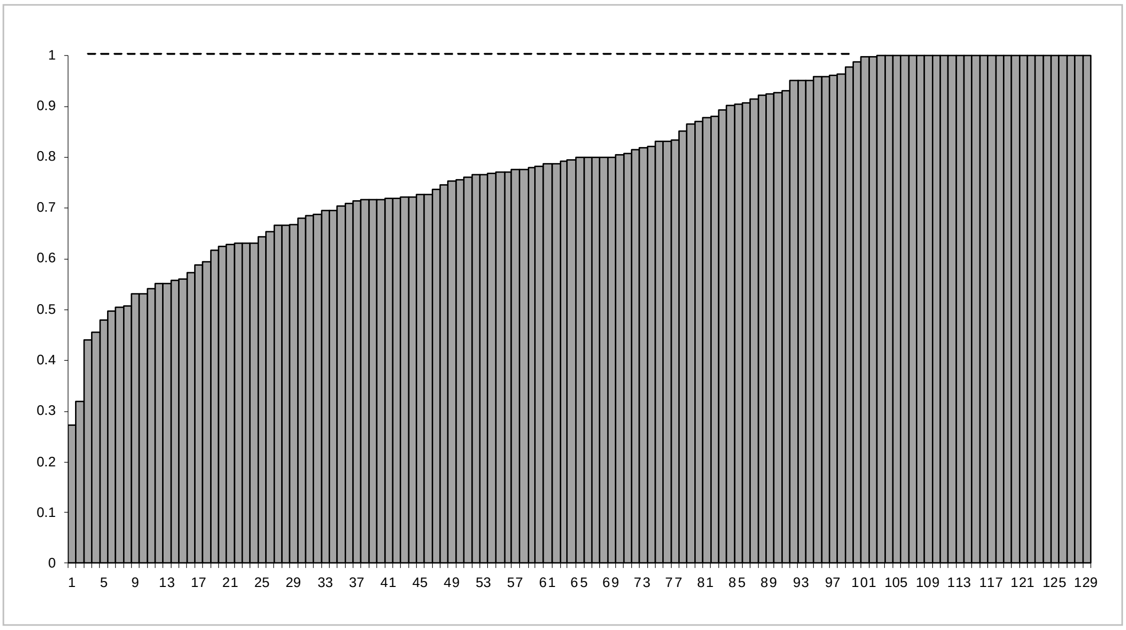

Figure 7: Preliminary efficiency scores for 129 projects (blocks of flats)

Each column in figure 7 represents one project. (In the final version each column will be given a width corresponding to the project's size (cost of construction, B-40). The figure shows considerable differences in efficiency. To the right is 27 projects with E-score = 1,0. These represent *best practice*. The rest of the projects are compared to a convex combination of these. The total improvement potential is indicated by the integral over the curve (the white triangle between curve and dotted line at level 1.0).

It is interesting to observe the improvement potential, especially if the 129 projects are part of the same economy. In our case there are 37 different companies behind the result. A group of five major companies have contributed with more than 10 projects each. For these, and in fact for all with more than a few project in the lot, the results are of specific value. The identities of the projects are anonymous, but each company can know the ranking of their own projects. Based on this a company will have valuable information of own performance and a basis for individual improvement initiatives.

3.3 Why are the Most Efficient Projects Most Efficient?

The projects representing best practice is of course of specific value. Together with data regarding resources and product, the questionnaire was used to collect information of *Environmental condition* and *Actions of the project management*, see figure 4. Approximately 500 questions about the two types of *explanatory factors* are answered by the project mangers and prepared for the step 2 of the efficiency analysis. By regression technique we are searching for explanatory factors that correlates with high efficiency, respectively with low efficiency. – After this huge numeric operation, and after having assured the quality of the research results by case studies of a few projects from the two extreme categories, we hopefully will have identified certain Environmental condition and Actions of the project manger that characterize each of the two groups. In he near future we hope to report also these Step 2 results.

4. Conclusions

The construction industry needs adequate tools to carry out benchmarking as basis for organizational learning and company development. Based on the DEA method and statistical analysis, NBI has carried out a pilot study where the main challenge has been identification and collection of necessary data and supplying facts. A questionnaire has been designed and answered by 138 project managers of assumed comparable projects of blocks of flats. The data consistency check and preliminary efficiency analysis make us believe that the method can be taken into use for continuously benchmarking of production of blocks of flats. We also believe that the model can be adjusted to suite other types of construction project. A simplified and refined questionnaire is the aim of the R&D project, used on a new set of data during 2005-06.

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The Motivation of Masons in the Sri Lankan Construction Industry

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Abstract

This research is an empirical study of human resource management (HRM) for the motivation of masons in the Sri Lankan construction industry (SLCI). The structured interview was chosen as a main research instrument for data collection. 90 masons and 30 supervisors were randomly selected from 10 construction sites within the SLCI.

The study's findings show that the supervisors and masons in the construction industry (CI) in Sri Lanka are aware of the supposed advantages of staffing, employee development and the rewards of a HRM approach. However, these characteristics have yet to play a significant role in the motivation of Sri Lankan supervisors and masons. A contextually sensitive application of these three strategies has the potential to improve motivation of the Sri Lankan construction workforce.

Keywords: Motivation of Masons, human resource management, Sri Lanka

1. Introduction

The management of present day construction projects is becoming increasingly complex and challenging due to many factors. To meet this challenge it is of the utmost importance to provide efficient management throughout projects. This research is an empirical study of human resource management (HRM) in the Sri Lankan Construction Industry (SLCI). The research focuses on the particular roles that staffing, employee development and rewards have in the motivation of masons in the SLCI. The study as a whole contributes to the wider debate on worker motivation.

2. Statement of the Problem and Significance of the Study

The construction industry (CI) is one of the most important industries in almost every country [1]. The crucial importance of the CI to a sustained development effort in a developing country cannot be overemphasised. Although construction is not an end in itself, it is the means for the achievement of the desired end, which is the development of new production capacity in the economy. In developing countries, productivity in construction has remained at a relatively low level compared to other major industries [2]. Therefore the effect of productivity on a nation's economy is highly significant. Improved productivity in the CI can have an important role in promoting national competitiveness and a satisfactory growth rate.

The Sri Lanka State Engineering Corporation, Sri Lanka Building Department, Sri Lanka Port Authority (SLPA) and Sri Lanka Labour Department have experienced that most of their projects are affected by low productivity and motivation [3, 4]. Most projects have also suffered from serious setbacks and even termination of contracts. In the SLCI, it is believed that productivity is low when compared to other developing countries and to the Asian sub-continent in particular [5]. One of the factors contributing to such low productivity is that of employees' motivation [6, 7, 8, 9]. However, in the ancient and colonial eras, the SLCI was properly organised, well motivated and highly productive [10, 11], although no evidence of the methods they used to manage and motivate construction employees still exists. It could be argued that without sufficient motivation of employees, such success could never have been achieved. Therefore motivation of Sri Lankan workers is one of the appropriate approaches to achieve higher productivity in SLCI. There is a large body of conceptual and empirical evidence concerned with the application of motivation theory to the CI [12, 13, 14, 6, 15, 16, 8, 9]. Unfortunately, there has not been so much empirical research on applying HRM strategies to the CI. No research about motivation was conducted for SLCI. The literature on motivational studies has flaws and weaknesses and is outdated [17, 18].

3. Motivational Theories vs. HRM Concepts

Motivational theories are also based on the functionalist paradigm, are not multi focused and do not give a real representation of how workers in construction are motivated. Most of them deal with intrinsic properties which are not sufficiently socially constructive for any credence to be given to them. The motivational theories, which take a functionalist view, offer only one perspective on the social construct. What is needed, therefore, are other methods of researching motivation in construction which embrace some of the salient points mentioned in social research theories [19]. Both the social as well as the scientific nature must be included in any study of construction worker motivation.

HRM is a socially constructed concept as opposed to the functionalist and traditionalist views of the motivational theories. Therefore, future studies of motivation of construction workers, in particular Sri Lankan construction workers, should embrace these modern, more pragmatic views of the social construct that are found within human resource management [20, 21, 22].

However, the traditional motivational theories used by previous researchers are dated: the researchers still talk in terms of managerial issues and personnel administration. These theories do not incorporate the different facets of human complexity and the evolving dynamic construction environment. They do not in any way play a significant role in shaping the self-identity of workers even though they have existed for a very long time. The main theme of this research is that motivation of workers cannot be separated from the context of the socio-economic environment. The extent to which perception of the workplace can be changed by HRM discourse is questionable in the case of construction employees' motivation. However, from this perspective, HRM plays an active role in understanding and constructing the social reality of the workplace and motivation of employees.

More crucial is the need to be aware of the strong links between the conceptual literature that has sprung up on HRM and the outdated empirical research that has been carried out on motivation. Themes such as staffing processes, employee development processes and rewards systems have to be understood. On the other hand, in Sri Lanka, Western management and HRM approaches have been employed in construction projects over the past few decades, without an assessment of the appropriateness of such approaches.

This has raised some crucial problems. The workers in the CI in Sri Lanka are aware of the supposed advantages of the HRM approach. The discourse of HRM in the SLCI has played a role in the motivation of the Sri Lankan workers. Effective and efficient application of HRM to Sri Lankan workers would improve their motivation.

4. Methodology

Research data were collected by means of a survey of masons in 10 construction sites in Sri Lanka. The data-gathering techniques were:

Interviews (one-to-one)
Interview sessions were the main research instrument in the study. 120 structured interview sessions were conducted and fully tape recorded. The interviews were conducted in Sinhala, which is the lingua franca of the Sri Lankan operatives.

Observation
10 observation sessions were conducted in 10 work sites within the SLCI. Structured observation schedule was used for each observation session. The findings of the observations were triangulated with finding from the interview sessions. Both techniques were pilot tested prior to the main research work.

5. Research Results and Discussion

5.1 Staffing Processes

Staffing encompasses the human resource activities designed to secure the right employees in the right place at the right time [23]. Management professionals in the construction industries making a decision to recruit employees must consider whether to rely on the external or internal labour market [24]. Among Sri Lankan construction firms, those with outstanding and average performance seem to be less informed about recruitment and selection processes.

5.1.1 Existing Staffing Processes in the SLCI

This research shows that the most common staffing procedures for supervisors and masons in the SLCI are as follows: advertising the vacancy, calling job applicants, conducting interviews, direct recruitment through personal contacts, friendship or any other form of relationship. Advertising the vacancy is more prevalent than other existing staffing procedures.

Direct recruitment through personal contacts, friendship or any other relationship sometimes causes favouritism and employment of unsuitable workers. However, there are some advantages to this system. Recommendations from a reliable source can guarantee the trustworthiness of employees.

Other methods for recruiting employees are not common in the SLCI. These include: direct recruitment, conducting a practical test of applicants' knowledge, conducting a theory test of applicants' knowledge, giving effective pre-work training, and using a registered list or recruitment agency. Although direct recruitment as a result of political influence is not common in the SLCI as a whole, it does play some part in direct labour recruitment. Direct recruitment due to political influence is detrimental to the company and results in similar difficulties to those discussed earlier in relation to direct recruitment through personal contacts, friendship or any other relationship.

The theory test of an applicant's knowledge is not especially suitable for masons and not prevalent in the SLCI. One reason is that most masons are not taught the rudiments of masonry theoretically. They start off as an apprentice to another mason, or as labourer who shows some interest in masonry work. Only 7% of supervisors and none of the masons mentioned the theory test method. In general, masons are not as well educated as supervisors – thus some Sri Lankan masons cannot understand the theory test. The practical test is more suitable for the recruitment of masons, because their job is completely practical, unlike that of supervisors. 62% of masons and none of the supervisors specified a practical test. Recruiting employees through an agency system does not exist in the SLCI. This is due to the availability of cheap labour. An employment agency system has not taken root in Sri Lanka.

5.1.2 Characteristics of Staffing Processes in the SLCI

The research results show that the existing characteristics of staffing processes in the SLCI, which have a response rate of more than 50%, are as follows:

- There are appropriate and adequate job design and analysis procedures (mainly concerned with how to recruit, how to select, how to train, how to develop, how to downsize, how to administer wages etc.)
- The organisation has clear staffing procedures
- There are recruitment plans to avoid unexpected staff (labour) shortages
- Staffing is designed to secure the right employee at the right place and at the right time

- The recruitment and selection processes are concerned with identifying, attracting and choosing suitable people to meet an organisation's HR requirements.

The above characteristics are perceived as being very important to the SLCI. There is a general willingness to include them in company practices. Unfortunately, only the first characteristic is currently functional. The reasons for the malfunction of the other characteristics can be identified as follows: financial and facility problems, the difficulty of introducing new methods, the difficulty of giving up old procedures, insufficient time because of a busy schedule, the difficulty of changing how the institution is perceived, management deficiencies and superiors' lack of interest in management procedures. A small number of employees cited other influences (e.g. political). However, effective management can help to prevent the above problems from arising.

5.2 Employee Development Processes

Employee development processes have become an integral part of most construction industries (25, 26). In general, both new and existing workers will require more training and employee development, especially in developing countries. The findings show that the employee development and training process is a highly valued function, but not adequately distributed amongst supervisors and masons in the SLCI. Only 12% of the respondents stated that they had satisfactory access to employee development processes. This is the result of the reluctance of employers to invest in employees due to uncertainties in the SLCI.

5.2.1 Existing Employee Development Processes in the SLCI

The survey results regarding employee development processes in the SLCI reveal that the following processes are both widespread and popular:

- On the job training by specially appointed people
- On the job training provided by senior employees
- Induction training at the beginning of employment
- A short duration training programme.

Most construction firms in the private sector offer only introduction training as an employee development process. Some private firms do not even offer this limited option due to their busy day-to-day schedule. This means some employees are starting work without any induction being offered by their employer. This can obviously result in poor quality work and low productivity, because company procedures are not well understood. On the job training by senior employees can sometimes prove detrimental to a company because of favouritism, or the passing down of work-related weaknesses from senior employees to trainees. On the job training by specialists can overcome the above disadvantages.

There are other methods (e.g. a firm's own training programme, frequent conferences) which are not common in the SLCI. Although uncommon when considered as a whole, considerable variation in response can be seen if the responses of the various groups are considered separately (e.g. masons only or supervisors only).

Most employee development processes in the SLCI are available to supervisors to a much greater extent than they are to masons. The supervisor's role involves more responsibility and is thus of more importance to the firm. Consequently, only 36% of masons but all of the supervisors have short introductory training programmes. Similarly, only 26% masons compared to 80% of supervisors experience their firm's own paid training sessions. It should be noted that some training sessions that are conducted for masons can prove to be very challenging due to the low literacy level of most masons within the SLCI.

5.2.2 Characteristics for Employee Development Processes in the SLCI

The characteristics of most employee development processes are that they are scanty and not fully functional. This can be clearly seen from the fact that in the survey, when asked to identify the existing and functional characteristics of employee development in the SLCI, the respondents only cited one characteristic with a response rate of more than 50%:

The management may decide to orient their training and development activities towards short-term or long-term objectives.

In reality, this characteristic cannot be said to be functioning adequately in the SLCI.

The findings show that all characteristics investigated in employee development processes in the SLCI are clearly perceived to be important but that there are significant obstacles to their successful implementation (e.g. financial and facility problems, lack of time due to a busy schedule).

5.3 Reward Systems

Another key feature of modern approaches to HRM, within the construction industry and elsewhere, is reward systems [26]. Generally, the structure of the reward package is related to the job, as well as to the expectations of the employee and the labour market. Reward packages consist of either a salary component or an incentive component, and can also be categorised as money related or non-money related [27, 24]. However, most Sri Lankan construction firms suffer from serious financial problems and are busy with day-to-day workloads. These firms still have poorly distributed reward systems. The superficial view is that most of the small private sector firms in Sri Lanka are often bankrupt and terminate contracts without having a chance to reap the benefits of reward systems. The study findings show that the majority of construction firms in Sri Lanka have some kind of reward system, but that these are inefficient.

5.3.1 Existing Reward Systems in the SLCI

Certain reward and incentive systems are currently in existence in the SLCI. The following are all being implemented with varying degrees of efficiency: a satisfactory salary is earned; a good reputation is achieved, good employer/employee relationships are achieved; satisfactory facilities are provided (e.g. housing, accommodation, etc.); satisfactory welfare facilities are provided; a satisfactory bonus is offered; overtime is offered; social activities are organised; appropriate quality training is offered; permanent jobs are offered; praise is given; rewards and certificates are given; performance appraisal programmes are conducted; and promotions are given. However, from the above list, only the following elicited a response rate of more than 50%:

- Overtime is offered
- A good reputation is achieved
- Praise is given
- Satisfactory facilities are provided (e.g. housing, accommodation, etc.)
- Social activities are organised
- Rewards and certificates are given
- A good employer/employee relationship is achieved
- A satisfactory salary is earned
- Permanent jobs are offered

Overtime is currently the most prevalent and popular reward system in the SLCI. Considering the high amount of absenteeism and the insufficient number of employees, management has to cover the day-to-day workload by giving overtime to existing workers. This explains the high incidence of overtime in the SLCI. However, management has to manage and plan the workload. It also has to take into account employees' work capacity and allocate overtime accordingly, otherwise productivity and motivation will be negatively affected.

Unemployment is a severe problem especially in developing countries and this situation is clearly true for SL. The opportunity to have a job is a significant motivation for Sri Lankan employees. It must also be remembered that the benefits and salary provided by employment within the SLCI are much higher than in other industries. Hence having a job in the SLCI is also a means of achieving a good personal reputation.

Expressing warm approval, respect and gratitude for high-quality work is also considered to be a reward system in SL. This reward can be easily provided and achieved. However, praise given to unsuitable employees can also negatively affect the motivation of others. Management has to be aware of this because the problem of favouritism is also widespread in the SLCI. Bearing in mind the economy and living conditions of the country, the provision of satisfactory facilities (e.g. housing, accommodation, etc.) is a reward valued highly by Sri Lankans.

Considering supervisors and masons separately, it can be seen that there are more beneficial reward systems available to supervisors than masons. 100% of supervisors and only 36% of masons have permanent jobs. 77% of supervisors and 53% of masons are satisfied with the social activities organised by their firms. Furthermore, the results show that there is only an 11% overall prospect of promotion in the SLCI. This is extremely low. The responses of supervisors and masons differ: 67% of supervisors and only 24% of masons stated that their firms have a clear promotion scheme. Offering training opportunities or facilities as a type of reward is more freely available to supervisors than masons.

Masons appear to be more satisfied with their salaries than supervisors, even though the supervisors' salaries are higher than those of the masons. According to the qualification, social status and comparison with other industries, masons are more satisfied with their salaries.

5.3.2 Characteristics of Reward Systems in the SLCI

The following characteristics are currently in existence within the reward system in the SLCI: the organisation has an efficient reward and incentive system; a reasonable performance appraisal programme exists in the organisation; money-related rewards are important; non-money-related rewards are important; group-related rewards are important; individual related rewards are important. There are incentives not linked to performance such as holiday pay, sick pay, long-service allowances, pension funds etc; there are incentives partially tied to performance such as profit sharing; incentives directly tied to performance; and the organisation keeps its payment structure up to date.

However, an examination of all the responses reveals that only a small number of characteristics can be said to be in existence to any significant degree. The following elicited a response rate of more than 50%:

- The organisation has an efficient reward and incentive system
- The organisation keeps its payment structure up to date
- Non-money related rewards are important
- Incentive is directly linked to performance
- Group-related rewards are important.

Although the respondents stated that all of the reward system characteristics were important to their firms and that they are willing to have them, the above characteristics are not functional due to financial problems as well as the inadequate resources and facilities available within the SLCI.

To summarise, the findings show that most supervisors and masons are aware of the supposed advantages of modern HRM approaches (i.e. staffing, employee development and rewards). They realise that these approaches can have significant positive effects on employee motivation, although they have yet to play a role in the motivation of the Sri Lankan supervisors and masons. Furthermore, supervisors and masons are aware of the motivation benefits, which can result from the implementation of the approaches. 95% of the respondents cited the motivational benefits (e.g. institutional and employee productivity is increased).

6. Conclusion

The study concludes that supervisors and masons in the construction industry in Sri Lanka are aware of the advantages of staffing, employee development and rewards in HRM; a contextual application of staffing, employee development and rewards for Sri Lankan masons would improve their motivation. The findings also show that the discourse of staffing, employee development and rewards in Sri Lankan construction industry have not played a role in their motivation.

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Measuring Productivity on Project Level

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Abstract

This paper presents a research project which developed a method and indicators for construction site productivity assessment as well as tested them on apartment-block sites. Productivity indicators were complemented by others representing explanatory factors, their purpose being to help identify best practices. Dependencies were studied, for instance, with the BayMiner data mining tool. The research is part of a joint venture of five Nordic countries implemented in 2001-2004.

Keywords: Productivity, efficiency, benchmarking, construction, data mining

1. Introduction

1.1 Overview

The Norwegian Building Research Institute, the Icelandic Research Institute, the Swedish National Testing and Research Institute, the Danish Building Research Institute and VTT have completed a three-year productivity study on the Nordic construction sector. Each country conducted a subproject focussing on itself. The findings were shared through the joint Nordic project. This paper describes the Finnish portion of the productivity study.

The main interest of a company in conducting productivity studies is to identify the factors which impact productivity. Knowing these factors makes it possible to improve internal processes. By collecting information from several projects, companies can identify the best practices for high productivity, and transfer them from one project to another. If the key factors for high productivity can be identified, productivity measurement can be an important development tool for a company.

The objective of this work has been to develop a methodology for measuring productivity on the project level and to conduct a benchmarking analysis.

1.2 Measuring Productivity in Construction

One focus of productivity research is the analysis of company-level productivity and analysis of the productivity development of various processes and work phases. Companies make use of productivity monitoring and indicators in developing their operations and technologies. Statistics Finland monitors productivity development on the national economic level, and the results are used in evaluating industries and their development needs.

In 1996 the construction industry and Statistics Finland conducted the *building construction productivity indicators* study. It defined productivity indicators for the entire building construction industry and its sectors. The study suggested measuring the productivity of the industry on three different levels. Annual development is monitored on the industry level by an index type indicator that does not depict the level of productivity but changes in it. Another level of measurement consists of value-added-based indicators for subsectors that show the absolute level of productivity. The third level involves monitoring labour productivity by product group- and building type-specific indicators which are by nature physical productivity indicators. [1] Statistics Finland launched the highest level monitoring suggested. However, sector organisations have not yet begun monitoring productivity on the other two suggested levels.

Companies are not in the habit of publishing their in-house productivity studies, but Helsinki University of Technology has persistently researched the performance of companies with them [2]. VTT has developed methods for determining the efficiency of the site process as part of the *Site process re-engineering in building construction* project in 2002-2004 [7]. The indicators of productivity measurement were studied in 1992-93 [13]. VTT has also examined the monitoring of productivity in infrastructure production. The project produced productivity indicators for the infrastructure sector and launched monitoring to test the developed indicators [12].

1.3 Implementation

The study investigated ongoing productivity research in construction in cooperation with Nordic research partners. In addition to Nordic research, it reviewed the English KPI (key performance indicators) method which was also tested by the Norwegians in an actual construction project. The Finnish subproject consisted of the following phases:

1. Definition of preliminary productivity indicators
2. Development of data collection models
3. Comprehensive data collection
4. Adjustment of productivity indicators and analysis of material
5. Reporting

Comprehensive data collection was implemented in the form of a questionnaire study targeted at the contact persons of participating companies using a multiple-choice Internet form. The response material was analysed by both the traditional normative statistical approach and so-called data mining based on the Bays Network. Reporting consisted of a public research report and a confidential report to each partner company.

2. Methodology

2.1 Approach

The evaluation of the performance of a complex process can be approached in two ways. One involves developing an indicator-type integrated gauge consisting of individual gauges that measure different features of the process as comprehensively as possible. The industry-specific overall productivity indicator can be considered one: it measures the combined performance of various subprocesses by a money-based indicator of added value and combines them into a single indicator.

Another approach to gauging a complex process is to use individual physical meters that provide the best possible description from the viewpoint of the performance of the entire process, while they actually only assess a single feature of the process. Gauges can also target the process preceding the process in question, the one following it, the use of process resources, or process control. For instance, process resource consumption can be used to evaluate also the performance of the process itself. This approach has been applied, for instance, to the assessment of the quality of the operations of a construction company.

The study approached productivity measurement by applying the principles of complex process measurement. Practical input-output parameters were defined in accordance with the concept of productivity: their ratio depicts productivity. To determine the factors that affect productivity, the impact of various control and environmental factors on productivity was analysed. (Fig. 1)

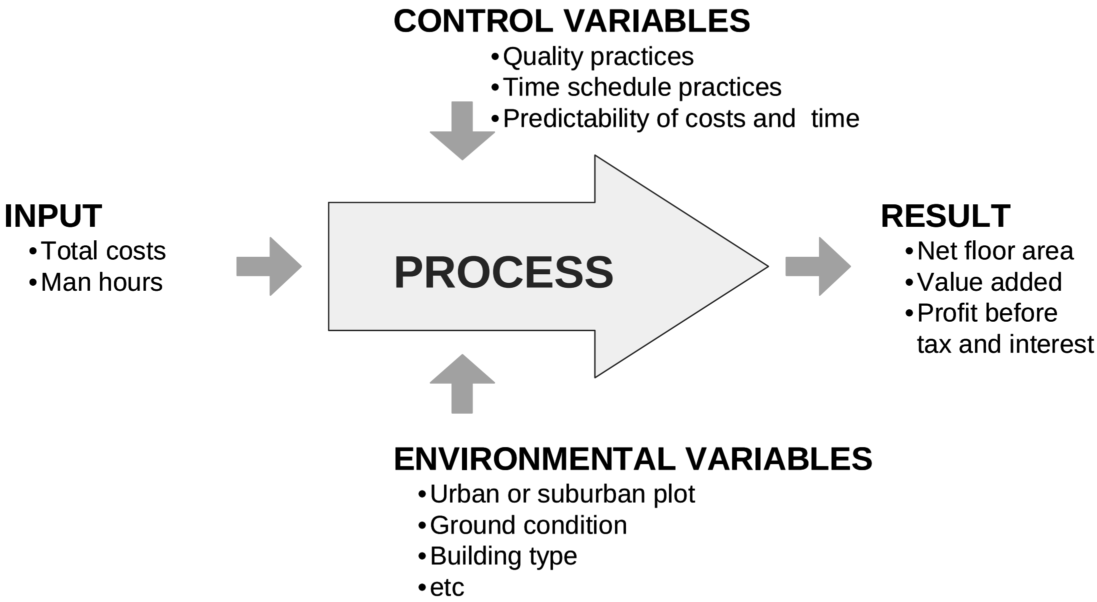

Figure 1. Productivity measurement by the input-output ratio. Control and environmental factors can help discover procedures and factors that explain good and poor productivity.

2.2 Explanatory Factors

For the purposes of this study explanatory factors were divided into control and environmental factors. Control factors are linked to things that the construction company itself can impact. The control factors examined in the study include, for instance, the quality procedures employed in the construction project, how intermediate scheduling goals were reached, what share of the costs had been realised at handover, and the degree of subcontracting.

The construction company cannot affect environmental factors itself. These include things like whether the building is located in an urban centre or a suburb and the foundation engineering conditions. Factors like the distribution of dwellings within the building and distribution of dwelling sizes were also considered environmental factors even though some of the projects were self-developed projects. It is naturally unthinkable that a builder would just construct large dwellings in a suburb pursuing higher productivity when demand focuses on small units in the central area.

2.3 The DEA Method

Data envelopment analysis (DEA) is used to rate the efficiency of organisational units against the best unit. Basically, the method tells what percentage of the inputs used by a unit would have been required for a certain output, had the unit operated as efficiently as the best compared units.

The method is suitable in instances where the evaluated organisational units produce a similar product. In Finland the construction products industry has tested the method at least in rating the productivity of facade element production. There the input was labour input in hours and the output the square metres area of produced elements. In other Nordic countries the method has also been applied to the measurement and comparison of the productivity of building construction. In building construction the benchmark project must be as comparable as possible.

In the DEA method the material is reviewed using a so-called Salter diagram or a so-called scatter diagram. In the scatter diagram resource consumption (input) is represented by the x-axis and the output produced by the organisational units by the y-axis. The surveyed organisational units are represented by dots in the diagram. A broken line drawn through the best organisational units indicates the realistic target level that all organisations could reach if their productivity was as high as that of the best units (Fig. 2).

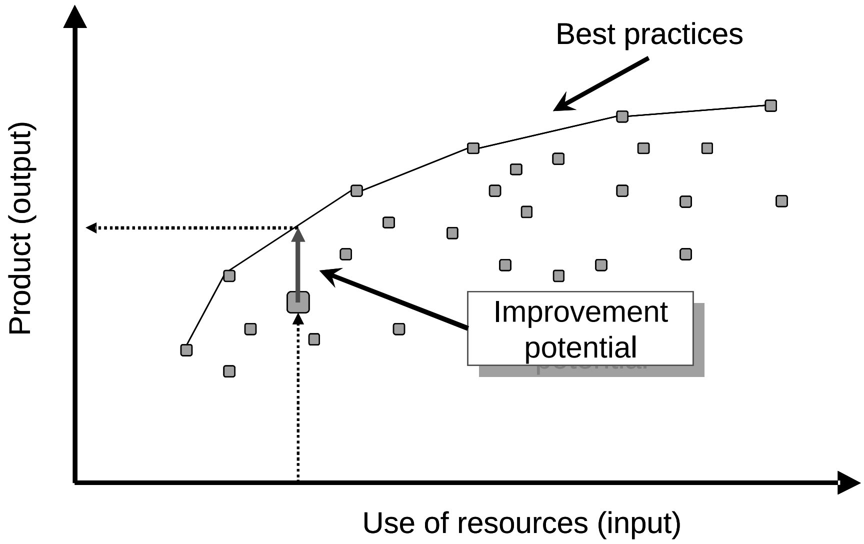

Figure 2. Scatter diagram. A broken line drawn through the best organisational units indicates the attainable improvement potential.

2.4 Bayes Network

The challenge of productivity research is to determine which practices actually are so-called best practices and place the project either in the good or bad category. Since we cannot tell beforehand which practices are good, it is worthwhile collecting as much data as possible on several potential explanatory factors. This leads to complicated analysis of causal relations.

In complicated reasoning tasks the lack of human knowledge can be replaced by calculation models, so-called computational intelligence, where part of the calculation model is based on collected measurement data on the subject. An expert may have a conception of the operation of the target process, but not enough knowledge about all causal relations. To produce a model capable of predicting the future, the missing parts are complemented by so-called computational intelligence [9].

Bayes Networks are decision-making systems based on probability calculation and, above all, so-called Bayesian decision-making. Probability distributions are assumed for all elements of modeling: the parameters applied to the model architecture and the data used for the purpose. The system then selects the most probable model and parameters considering the measured data.

Construction of a model based on the Bayes Network is possible using complex algorithms and requires high computing power. The advancement of IT has, however, made it possible to calculate efficient algorithms, and applications built on Bayes Networks have also seen commercial use.

Bayes Information Technology Oy has developed an efficient data mining tool based on the application of the Bayes Network for statistical processing of material. The BayMiner software is used via the Internet as a so-called ASP service. The BayMiner software is also suitable for analysing research problem setting, i.e. determining which control and environmental factors explain the construction project's ending up among good or bad ones (Fig. 3) [10].

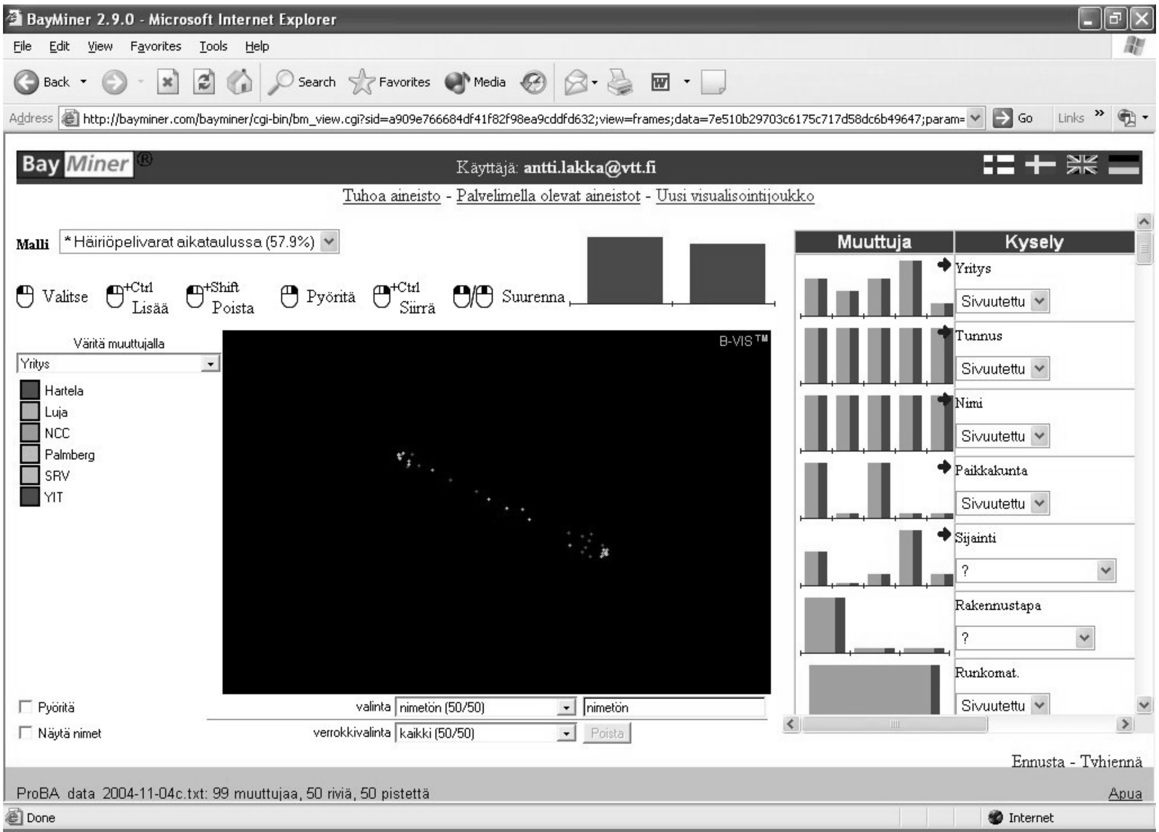

Figure 3. User interface of BayMiner data mining tool. The software was developed by Bayes Information Technology Oy.

3. Comparative Study

3.1 Sample

Apartment-block sites were selected as the subject of productivity comparison: they were thought to be sufficiently alike to allow site-level productivity comparison. The subject was limited to new construction, and comparison targeted the site phase of the project. Cost items external to the site were excluded such as the acquisition cost of the plot and profit margin. Confining the survey to realised costs limited usable productivity indicators to physical ones. For instance, a value-added-based productivity indicator based on the value added to the company per person-year was thus excluded.

Sample size was 50. Data on some was deficient and consequently comparisons were based on a reduced sample. The typical sample size for surveying explanatory factors was 43.

3.2 Productivity Comparison

A productivity indicator that treats different types of apartment-block construction as impartially as possible was sought to allow distinguishing "good" building projects from "bad". The goal was a practical gauge that provides a reliable indication of the productivity of compared projects for which input data is available from projects of various construction companies. The input of the selected productivity indicator consisted of the consumption of resources on site in monetary terms, i.e. realised site costs in euros. The selected output was the volume of site production in net floor area.

In Fig. 4 the sample of the comparative study is plotted in a so-called scatter diagram. A broken line was drawn to connect the points representing the best performing projects to indicate the highest attainable productivity. For instance, one building project used about €3.5 million in resources to produce a net floor area of 2,200 m^2. The best project, on the other hand, used the same amount of resources to produce nearly 3,500 m^2 of net floor area.

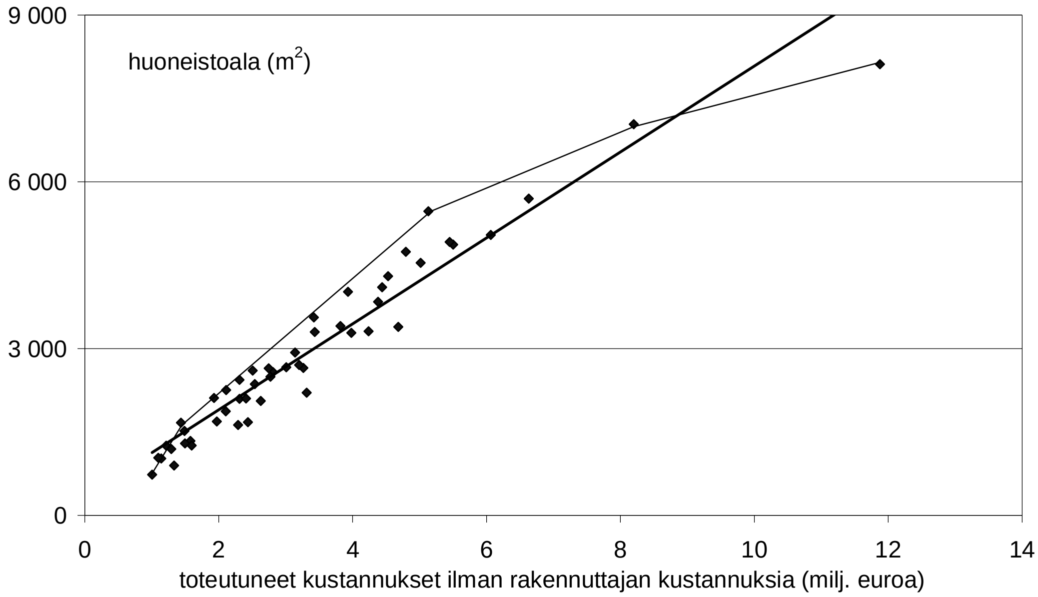

Fig. 4. Scatter diagram: output of building project [net floor area] in relation to used resources [realised construction costs]. Sample N=50 apartment-block projects.

In the comparison of projects special attention was given to the comparability of input data. For example, the content of different sets of area data in the sector has been defined quite well on the national level and can be considered comparable. On the other hand, the comparability of cost data is less certain.

In the study an attempt was made to secure the comparability of subjects by excluding the client's costs and by concentrating on site costs. The results of a productivity comparison are also impacted by the quality level of buildings since the quality level of units built wasting resources may be higher which also raises their sale price.

In addition to finding productivity indicators, the study also tried to define other key indicators which would allow dividing the sample projects into good and bad ones. Such an indicator is the predictability of costs represented by the ratio of realised costs to planned costs.

One indicator that proved good during the study is the ratio of realised profit margin to planned profit margin. The major advantage of that indicator is its neutrality towards different projects whose target margins may differ widely. The indicator based on a change in profit margin was not, however, tested in practice during this study.

3.3 Factors Affecting the Success of a Building Project

So-called best practices may underlie the success of good projects measured by different indicators. Indicators are also susceptible to various environmental factors which the site cannot impact even if they are known to have an advantageous or adverse effect on the result of the productivity indicator. The relationship between explanatory factors and productivity was studied using BayMiner data mining tools.

The explanatory factors used in the study could not, however, identify good procedures. The reason is that the selected explanatory factors were too common. For instance, using applied quality procedures as the explanatory factor could not provide additional information about good projects since nearly all apartment-block projects apply the same quality procedures. The situation would be different if quality procedures were just being launched and different projects applied different procedures. The scheduling practices used in the studied material were also in line with the prevailing good production practice, and there were no differences between projects in that area.

The analysis of environmental factors revealed that the best projects based on the selected productivity indicator were all outside the metropolitan area. The explanatory factors were the parking and foundation engineering solutions which increased costs per useful area. There may also be other factors that raise or lower costs which were not detected on the basis of the studied material.

4. Conclusions

4.1 Methodology

The developed research method was found to be, on the whole, usable in measuring site-level productivity. It is important that the productivity indicator is complemented with other performance indicators since it is difficult to establish a single site-level productivity indicator that is descriptive enough. It was also discovered that the data mining tool based on the Bayes Network is suitable for analysing explanatory factors in a site-level productivity survey.

The research found that indicators that explain and complement actual productivity indicators should be quite accurate – preferably ones that depict site processes. It would be good to select the measured processes serving as the explanatory factor from among recently launched site processes since differences still exist between them. In an ideal case someone has made an educated guess in advance about the impact of a certain factor on the project turning out good or bad. Then, the method used in the study could verify the accuracy of the prediction and thereby confirm the procedure as a good one.

4.2 Productivity Indicator

The productivity of a construction company or project can best be measured by a value-added-based productivity indicator. The indicator output is the monetary value added to the company or project. The indicator input consists of the labour input within the company or into the project, measured, for instance, in person-years.

Physical productivity indicators are most suitable site productivity indicators. The output may be produced useful area, and the input construction costs or own labour input on site in person-years. The problem with physical productivity indicators is that they are not comparable between highly different construction projects.

4.3 Suggestion for a Site Performance Indicator

It is suggested that site performance be assessed based on a profit-predictability figure indicating the ratio of realised profit to target profit. Profit predictability is a comprehensive indicator of the success of site operations. Its significant advantage is its neutrality vis-à-vis different projects whose target profits may vary widely.

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Section IV

Project Delivery Systems and Contractual Practices

Experience on a PPP-based High Speed Road Maintenance Project in Hong Kong

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Abstract

There is a growing trend for governments worldwide to explore new routes for procuring infrastructure facilities, such as various forms of Public-Private Partnerships (PPP), due to restricted fiscal budgets and an increasing demand for infrastructure facilities. Many practitioners and researchers believe that PPP can harness flexibility, encourage innovation, enhance productivity, allow better risk allocation, increase value–for-money, and improve cost-effectiveness by involving the private sector in the provision of public services. A Work Department of the HKSAR Government (the Department) has recently introduced the concept of PPP into their road maintenance programmes – the High Speed Road Maintenance Contract. The project is an interesting challenge to relevant public authority as the form of contract, project organisation, risk allocation and points of responsibility are totally novel. Most of the infrastructure projects using PPP approach are of much larger scale and are in the form of PFI so that the private sector is responsible for financing, constructing and maintaining the road network. The experience gained from this project, and especially its success would improve our understanding on whether PPP is suitable for similar road maintenance projects around the world. Before investigation of the success level of the new project, it is important to study the view and standpoint of the stakeholders on the issue of PPP as the human factor is believed to be a crucial contributor to the success of PPP. The paper begins by outlining the nature of the PPP high speed road maintenance project. As there is potential for the Department to extend the use of PPP approach to other road maintenance projects, a questionnaire survey conducted with other potential stakeholders of future PPP projects of a similar kind are presented to examine the effectiveness of the new PPP contract from their perspective.

Keywords: Public-private partnerships, high speed road maintenance, questionnaire survey

1. Introduction

Public-private partnership (PPP) is becoming an increasingly popular option of project delivery for governments. In view of the restricted fiscal budgets and the growing demand for infrastructure facilities, governments worldwide are striving to explore the use of private sectors' resources and particularly to involve private finance in the construction of facilities for the purpose of providing services. Many practitioners and researchers believe that PPP can harness flexibility, encourage innovation, enhance productivity, allow better risk allocation, increase value-for-money, and improve cost-effectiveness by involving the private sector in the provision of public services. It is also believed that PPP can improve project procurement environments and the relationship between project participants by changing the traditional adversarial scenario to cooperative partnerships [1].

The idea of PPP is not new to Hong Kong. Since the late 1960s, Hong Kong has gained valuable experiences from the successful development of five large-scale tunnel projects using the Build-Own-Transfer (BOT) arrangement [2]. In 2003, the HKSAR Government (the Government) has set up a clear goal in developing the city into a society with "big market, small government" [3]. This new principle of governance is supported by the idea that government should "steer more and row less" and that the role of government should be "proactive market enabler" [4]. In response to that, the Government has begun to explore different options of private sector participation. Several guidelines were published aiming to encourage the use of the private sector in serving the community. The Chief Secretary for Administration, Donald Tsang pointed out in the foreword of the guidelines that it is the responsibility of the Government to make the best use of both the public and private sectors so as to ensure that government activities do not dominate the market and would not absorb more of the gross domestic product than is optimal for economic success. With the help of the private sector, the Government can then focus its limited resources on identified priorities. [5]. In addition to new infrastructure projects, the Government is also being proactive in examining existing activities to determine whether they can be provided by the private sector, and the use of PPP would be explored for both traditional and innovative projects [6]. By moving tasks into the private sector, the Government believed that employment and business opportunities can be developed and expanded in ways that are simply not possible within the public sector [7]. In this paper, the effectiveness of PPP is examined through a pilot PPP maintenance project in Hong Kong.

2. Case Study in Hong Kong

Aligning with the government direction, a Work Department of the HKSAR Government (the Department) has introduced the concept of PPP into their maintenance contracts and a trial project, the High Speed Road Maintenance Contract was started last year based on the PPP approach. Being different from Private Finance Initiatives (PFI) – the most common form of PPP, this project involves no financial investment from the private sector. While many people equate PPP to PFI after its introduction by the British Conservative Government in 1992 [8], PPP actually has a much broader scope. It is defined as a cooperative venture between the public and private sectors for the delivery of a public service through appropriate allocation of resources, risks and rewards [9]. The ultimate objective of PPP is the joint realization of commercial and social benefits between the two parties [10].

2.1 Problems in Traditional Term Contract

The traditional high speed road maintenance project is in the form of a term contract. Staff from the Department are responsible for general road inspection to identify defects on the road which require work to be carried out. Work orders are then issued by the Department to the contractor for carrying out the corresponding maintenance work. There is full time supervision on the contractor to ensure the quality of work. Upon completion of the work order, the amount of work done by the contractor is measured and payment is given to the contractor according to the agreed rates stated in the contract. The traditional system of the maintenance project is considered as insufficient, since the amount of maintenance work to be carried out is budget driven instead of as-need. In addition, it is time consuming and tedious to deal with the large amount of work orders. A great amount of resources is also required for carrying out the measurement, estimation, accounting work as well as inspection and full time supervision. There is no room for innovation in the traditional term contract as the method of work is specified in the contract and little flexibility is allowed. Maintenance work is also considered to be inefficient in the traditional term contract. Long and complicated procedures are required to be gone through from the time of defect identification or receiving complaints to issuance of work order.

2.2 The MOM Contract

As a result of the deficiency in the traditional system of road maintenance and in response to the Government announced policy, the Department has taken a step towards PPP. It aims to improve the efficiency, performance and cost-effectiveness of high speed road maintenance project through involving private sector resources and enhancing cooperation between the two parties. To test the successfulness of PPP in high speed road maintenance project, a new project based on the PPP approach was started in 2004 by the Department using the western network of the high speed roads as a trial. By drawing upon the experience learnt from the trial project, other high speed road maintenance projects may also adopt a PPP approach on completion of its existing term contract.

The new high speed road PPP contract has taken the form of a Management, Operation and Maintenance (MOM) Contract and is a performance-based maintenance contract. In this project, the contractor is responsible for providing scheduled road maintenance services including road inspection, planning, design and supervision for repair and minor improvements of roads and highway structures, as well as for handling complaints from the public during the 4 years contract period. The management and maintenance works required to be carried out by the contractor are grouped under 3 main work orders which were issued at the beginning of the contract period. The major work items in the work orders are highlighted in Table 1 below.

Table 1: Major work items covered in the three work orders issued at the beginning of the contract

Work Order 1	**Work Order 2**	**Work Order 3**
1. Provide network manager 2. Maintain road markings and road studs 3. Maintain road drainage system 4. Conduct routine maintenance inspections for slope and undertake maintenance works	1. Conduct road safety inspection and undertake general road maintenance works 2. Conduct road detailed inspection and undertake general road maintenance works 3. Conduct structural inspection and undertake structural maintenance works	1. Maintain vegetation 2. Sweeping road by mechanical sweeper 3. Picking up litter 4. Cleansing traffic signs and the like 5. Cleansing carriageway 6. Maintain road network in hygienic condition 7. Operate calls receiving centre 8. Provide electronic maintenance management system

However, only 65% of routine maintenance works are covered under the PPP part. The rest of the non-scheduled, unplanned works are carried out according to the traditional work orders system. The contractor is entitled to a lump sum payment for the PPP component. Monthly audits would be carried out by the client's representative to determine the level of payment that the contractor can receive according to the predefined performance yardsticks. Samples are selected for audit is carried out on a random basis and 24 hours' notice would be given to the contractor before the audit. In addition to monthly audit, with no advance notice given to the contractor, the Department's staff would also continuously carry out road defects inspection on the road network. Default notice would be issued to the contractor on identification of any defects and a fixed sum of money would be deducted from the contractor. It is believed that the performance-based payment system can allow greater flexibility, encourage innovation, enhance efficiency and improve cost-effectiveness of work by allowing concurrent engineering of functions, use of new materials and techniques [11]. The performance standard of the contractor is measured by a set of benchmarks in different areas of works as specified in the contract. For example for road markings, a continuous road marking line with more than a certain percentage loss of paint in any given section length would be counted as a defect. The lump sum payment entitled by the contractor would be adjusted according to the number of defects discovered by the client's representative in the audits. Table 2 illustrates the differences between PPP and traditional approach in the high speed road maintenance contract.

Table 2: Comparison between PPP and traditional term contract

	Traditional	**PPP**
Form of contract	Maintenance term contract	Management, operation & maintenance contract
Terms of payment	Schedule of rates	Lump sum
Payment mechanism	Work-based (payment according to amount of work done)	Performance-based (reduction of monthly sum if performance standard not reached)
Specification	Method specification	Performance specification
Quality control	Full time supervision	Inspections & monthly audits
Road defects inspection	By staff of the Department	By the contractor
Time to carry out maintenance work	On receiving work order from the client	Immediately after identification of defects
Duties of client	Estimation, measurement, issuance of work orders, road inspections, full time supervision, programming of maintenance works	Audits and ad hoc Inspections
Duties of contractor	Maintenance work according to work orders	Road inspections, operation of call receiving center and electronic maintenance management center, planning and programming of works, general road maintenance
Documentation	Work orders (by client)	Work programme, report of finished work (by the contractor) Inspection records & site audit checklists (by client)
Types of work covered	All types of maintenance work	Routine & scheduled maintenance works
Relationship	Principal – agent	Peer – peer

2.3 A New Form of PPP

The new maintenance project is a great challenge for the Department as the form of contract, project organization, risk allocation and points of responsibility, etc. are all novel to the Department. No other similar project has ever been carried out before. Most of the overseas maintenance projects using PPP approach are of much larger scale and are in the form of PFI, which means the private sector is responsible for financing and constructing the new roads together with the subsequence maintenance of the road network. For example in Singapore, according to the PPP Handbook for public consultation [12], PPP is a form of “best sourcing” that mainly used in cooperation with the private sector to deliver services that require the development of new physical assets. Some of the staff in the Department also believed that the optimal and ideal form of PPP project should be one which starts from the capital works and continues with the maintenance works. This can encourage the contractor to uplift the construction quality so as to save its future maintenance cost. The contractor can then be paid on the “user pays” principle through the operation of toll roads. However, this kind of PPP in highways schemes may be difficult to be carried out in Hong Kong. It is because the road network in Hong Kong is almost fully developed, and very few new roads will be constructed in the near future. For the renovation of old roads or other road improvement works, it is difficult to convince the contractor to finance the work and be paid back through operating the toll roads without a good business case. Like other BOT-type projects, there would be practical, social and cultural difficulties as it is a radical policy change to charge on a user-pays basis for services that traditionally had been provided free of charge by the government [13].

3. Research Methodology

At the time of the research, the high speed road maintenance project using the PPP approach has only been implemented for less than a year. Therefore, not much data can be collected for evaluating the cost effectiveness of the project and the performance of the contractor under PPP. However, as there is potential for other road maintenance projects to migrate to PPP, views of other staff within the Department as well as other contractors should also be collected to uncover their views on the new PPP approach. It is believed that their opinion would be more objective and without bias as they have not been involved in the PPP project. In addition, since the human factor would also be a crucial criterion for the success of PPP, it is important to study the attitude and perspective of other stakeholders towards the new approach. This may be helpful in developing a PPP culture among the stakeholders within the organizations.

A questionnaire survey had been conducted with some potential stakeholders of future PPP projects to examine the effectiveness of the new PPP contract from their perspective. They include different levels of staff from the Department in various groups of maintenance projects (including both high speed road and local road) as well as contractors who have been involved in traditional term contract. A total of 33 respondents completed the questionnaire, of which 26 were from the Department and 7 were representing the maintenance contractors. The profile of the respondents is shown in Table 3.

Table 3: Designations of respondents

The Department	
Engineer or Technical Officer	12
Inspector of Works	6
Work Supervisor	8
Contractor	
Manager	2
Site Agent	5

The questionnaire consists of 17 statements regarding the cost and effectiveness of the PPP contract. To improve the understanding of the respondents, a brief introduction to the new PPP approach was provided to them as a preamble to the questionnaire. Depending on their level of understanding, questions were explained in greater detail and reasons for their answers were sought through face-to-face or telephone survey.

4. Questionnaire Findings

The results of the questionnaire show that the respondents from the contractor group generally have more positive views on the effectiveness of PPP while the responses from the Department's staff are more diverse. Many of them might have had some reservations in answering the questions. In this paper, only part of the questionnaire findings (in the aspects of time, cost and quality) are presented.

4.1 Effectiveness of Contractor-led Inspection

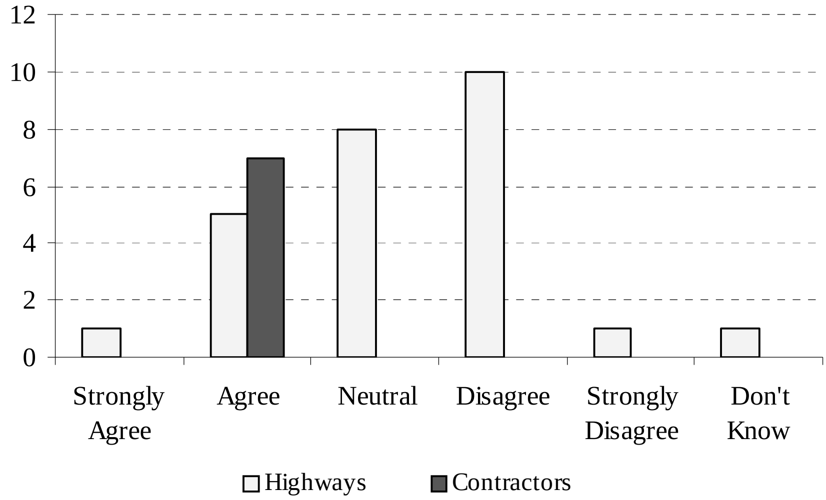

Figure 1: Effectiveness of contractor-led inspection in identifying defects

As shown in Figure 1, all respondents from the contractor group agreed that inspection carried out by the contractor is more effective in identifying defects than that carried out by the client representative. They claimed that the contractor can take the initiative to work and more resources can be devoted for full-time inspection. It was believed that payment reduction on defects discovered is also an important factor driving the contractor to more effective inspection. On the contrary, most respondents from the Department (11 out of 26) disagreed with the statement. They thought that the contractors in Hong Kong do not have self-discipline and supervision is required to monitor their work. There is also large percentage of the Department's staff (8 out of 26) expressing neutral view on the statement. They thought that the effectiveness of inspection depends on many factors including the tender cost, audit requirement, individual initiatives, human resources input, as well as qualification, training and experience of the inspectors. Some staff of the Department agreed that contractor-led inspection would be more effective. They believed that the contractor would have more resources and can have a dedicated team to take charge of inspection, whereas in a traditional term contract, there is not enough staff from the Department for the inspection work and the inspectors are always tied up with other duties at the same time. In addition, any unrectified defects would contribute to payment reduction. Thus the contractor would devote more effort in the inspection work.

4.2 Efficiency of Maintenance Work

Regarding the efficiency of maintenance work, nearly all respondents from the contractor group agreed that work carried out through PPP approach is more efficient than traditional term contracts. It is because work can be carried out directly without waiting for the issuance of work order. The majority of respondents from the Department also agreed with the improved efficiency due to the streamlined procedures and better programming of work. Time can be saved in preparing work orders which are tedious and time consuming to prepare. Some respondents had negative opinions on the efficiency of the work. They believed that the contractor would tend to leave the work until a later stage during Cyclic Lane Closure (CLC), while in the past, staff of the Department can issue work orders to instruct the contractor to finish the urgent work immediately. They thought that there is limited control on the contractor in the PPP contract.

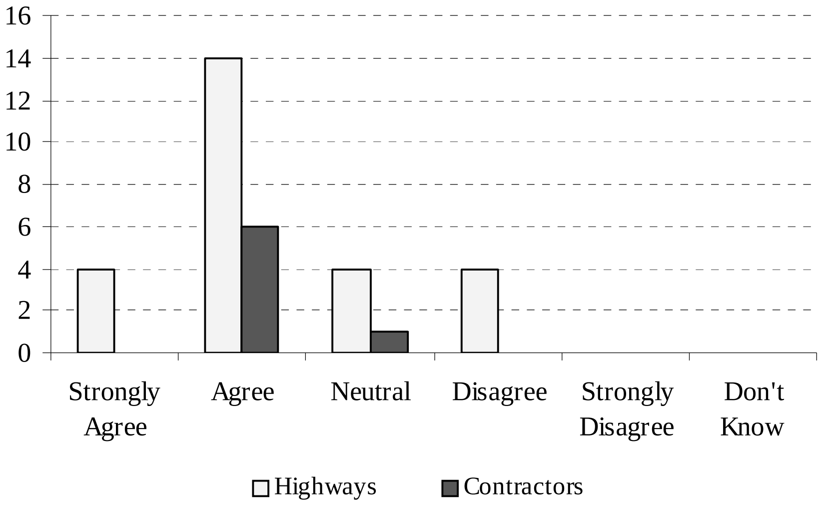

Figure 2: Efficiency of maintenance work carried out through PPP approach when compared with traditional term contracts

4.3 Amount of Documentation

For the amount of documentation, most respondents from the contractor group claimed that the amount of documents the contractor has to deal with has greatly increased. The contractor has to submit their programme and completion report to the client. On the contrary, most respondents from the Department (12 out of 26) agreed that the amount of documentation can be reduced in PPP contract due to the great reduction in amount of work orders. There would no longer be estimation, measurement and checking of work completion. However, some respondents argued that there would be additional documents like default notice, inspection report and audit report resulting in a similar overall amount of documentation.

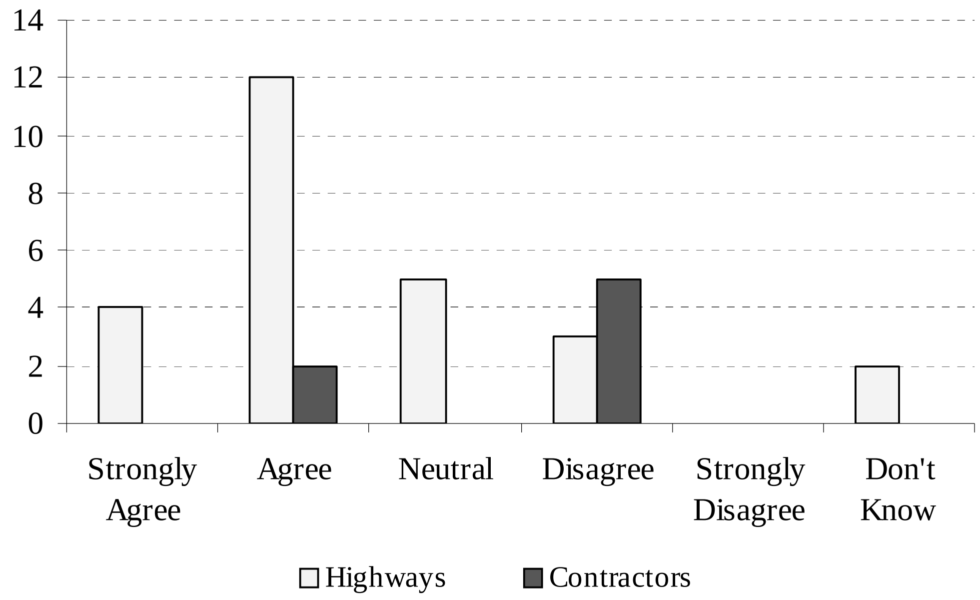

Figure 3: Potential of reducing the amount of documentation

4.4 Amount of Administrative Work

4 out of 7 respondents from the contractors believed that the amount of administrative work would be more than the past as the scope of work of the contractor has increased. Most respondents from the Department believed that the amount of administrative work can be reduced due to streamlined procedures and better communication. They no longer need to prepare or sign work orders for works under the scope of PPP.

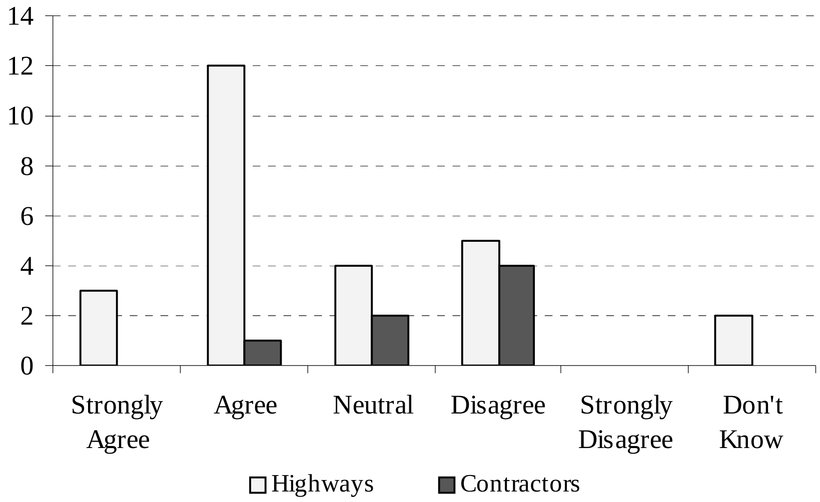

Figure 4: Potential of reducing the amount of administrative work

4.5 Staff Cost of the Department

As shown in Figure 5, most respondents from the two groups also agreed that staff cost of the Department can be reduced. It is because most of the work has been taken up by the contractor, including inspection, coordination and planning. There is no longer full-time supervision on the contractor and thus the number of supervisor can be reduced. Besides, preparation of work orders, estimation, measurement and accounting work can also be reduced. Some respondents argued that staff cost of Department depends on the contractor's performance. It would require more audits if the performance of the contractor is poor.

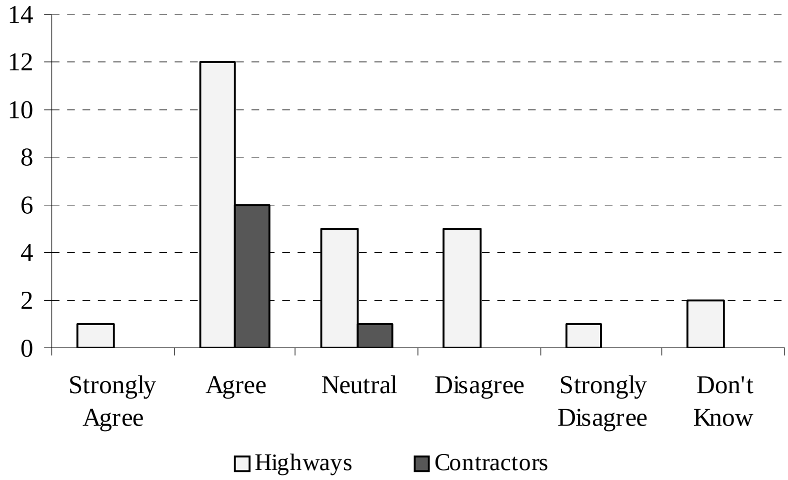

Figure 5: Potential of reducing the staff cost of the Department

4.6 Overall Cost Effectiveness

As shown in Figure 6, many respondents from the contractor group (5 out of 7) and the Department group (11 out of 26) believed that PPP would be more cost effective than a traditional term contract in the long run. Some staff of the Department surveyed postulated that the overall cost effectiveness depends on the tender price, the conditions of contract as well as the contractor's performance. More resources are required if the contractor is not good.

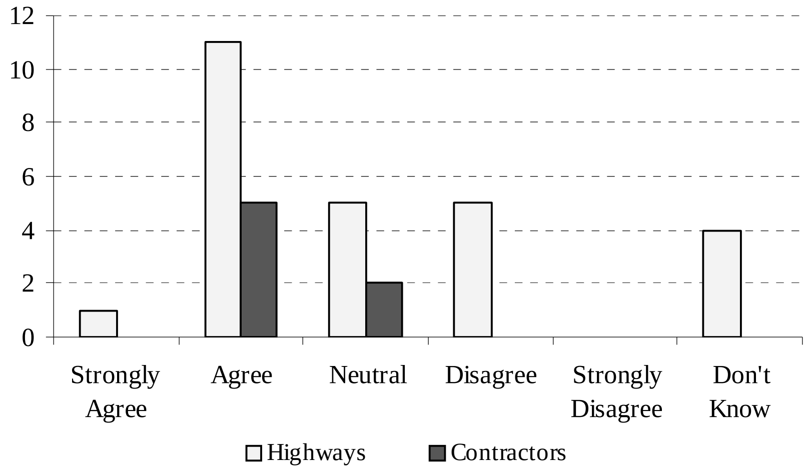

Figure 6: Overall effectiveness of PPP when compared with traditional term contract

5. Conclusion

The idea of PPP has been widely adopted in many countries over the world. It has mainly been used in large-scale capital or infrastructure projects in the form of PFI. The Department of Hong Kong has extended the use of PPP to their maintenance contracts. A new project, the high speed road maintenance contract was launched in 2004 using the PPP approach. It is a form of MOM contract with the contractor being responsible for the management and maintenance of the high speed road as well as operation of the call receiving centre throughout the four years contract period.

To study the potential for future development of PPP in other maintenance projects, a questionnaire survey was conducted to study the perspectives of potential stakeholders of future PPP projects on the effectiveness of the new PPP contract. The results from the survey indicate that most respondents supported the use of the PPP approach and agreed that it would be more cost-effective than the traditional term contract. They believed that the new approach can help by bringing in operational efficiencies, cost savings and better output performance.

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DBB, DB or DBM?
Performance of Road Project Delivery Methods

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Abstract

Internationally, road procurement is moving towards more integrated services. At the same time, the number of alternative project delivery methods has increased making selection of the best one difficult. The client must understand the features of the methods in order to select the most effective ones. That is why the presented study compared the performance of Design-Bid-Build (DBB), Construction Management (CM), Design-Build (DB) and Design-Build-Maintain (DBM). Based on the analysis of road procurement, more integrated services give better value for money and are of more help to the client in attaining his goals than more traditional methods. Yet, one should realise that each method has its typical applications, and all methods are not suitable for all purposes.

Keywords: Road procurement, project delivery, performance, comparison, life-cycle

1. Client's Changing Needs as Starting Point

Project delivery methods where the implementer offers more integrated service packages are increasingly used in infrastructure projects worldwide. The client no longer splits up the project to procure different types of services by different contracts. Besides construction, at least technical design and maintenance for a certain time period, often also financing, are covered by a single contract. The change in the modus operandi is the result of clients wanting to focus on their core businesses as managers of infrastructure networks as well as the overall aim of generating added value.

Generally, broader service packages have been assumed to allow optimising the product and implementation as a whole as well as to actuate sector development. Yet, contrary views in favour of traditional methods are also voiced: splitting up the project into small components is believed to increase competition in the markets and ensure the client's decision-making power concerning the details of the project. This together with other presented critique raises the issue of the usability and actual effectiveness of various delivery methods.

2. Performance Assessments as the Goal

The presented study charted the performance of different delivery methods in road procurement from the international viewpoint focussing especially on three areas:

- Examination of the operating principles and present performance level of various methods in actualized road projects.
- Assessment of the development means and potential of delivery methods and their resulting future performance.
- Anticipation of changes in the operating environment, and evaluation of their impact on the usability of different delivery methods.

Since there is special interest towards Design-Bid-Build (DBB), Design-Build (DB) and Design-Build-Maintain (DBM) in Finland, the study was to analyse the performance of these delivery methods and their applicability. As the municipal sector uses Construction Management (CM) it was also included in the comparison to some extent. Different financing solutions and costs as well as (indirect) social impacts were excluded from the study.

3. Charting of International Experiences

The study looked at the experiences gained from different project delivery methods in England, Australia, New Zealand and the United States in addition to Finland. An earlier study [3] found these countries the most innovative, which was presumed to mean that they were best poised to answer questions about new methods. Data were collected by interviewing over 60 persons representing different project parties in these countries and by charting and making use of studies conducted there and in other countries [1]. In the assessment of the merits of the delivery methods, the client's viewpoint was emphasised. The viewpoints of the contractor, designer and end user were also considered in order to ensure the support of all parties for the methods. Only that ascertains the positive future development of the sector.

In the studied countries there is a clear trend towards more integrated services and more risk borne by service providers. DB has gained ground on DBB and even replaced it completely in some countries. It is considered effective in procuring roads since it shortens project duration thereby improving cost certainty. Just about the only problem seen with it is the cooperation between the parties (especially designer/contractor) which various joint enterprise models seem to be able to address.

Various applications of DBM have also been used alongside DB since the 1990s to improve the life-cycle economy of roads. The applications have ranged from fully client-financed roads to pure toll roads. With the former, the enlarged responsibility of the private sector covers only 10-year maintenance whereas in the case of toll roads the project company collects revenue in the form of user fees over a contract period of 30-40 years. DBM has led to effective operation in terms of quality, schedules and costs. Yet, for instance, the used payment bases have also been criticised.

CM has been used hardly at all in road procurement. Finnish experiences of CM indicate some benefits from it although, at the same time, the fact that buying small work packages does not allow the industry to develop drew criticism.

4. Cost Savings through Integrated Services

Each phase of a project (procurement, design, construction and maintenance) involves a certain cost and duration. Costs may be incurred by the client's organisation (procurement, supervision) or industry (tender preparation, design, construction, maintenance, consulting). In the study, the interviewees indicated the actual phase-level, party-specific cost changes of various delivery methods compared to traditional procurement based on projects they have carried out. The costs for comparing different delivery methods were calculated on the basis of relative costs where the starting point was the cost structure of two reference projects. The chosen study period was 30 years, and delivery methods were compared on the basis of the present values of their costs.

The analysis [2] showed that DBB is the slowest and generally leads to the highest total costs in road procurement as shown by Fig. 1. CM speeds up project implementation, but costs about as much as DBB. The duration of a DB project may be slightly longer than in CM due to the longer procurement phase, but shorter than with DBB. On the other hand, the costs are clearly lower than with the CM and DBB. However, DBM is the one that yields the largest savings. In DBM the project takes a little longer than in DB and especially CM.

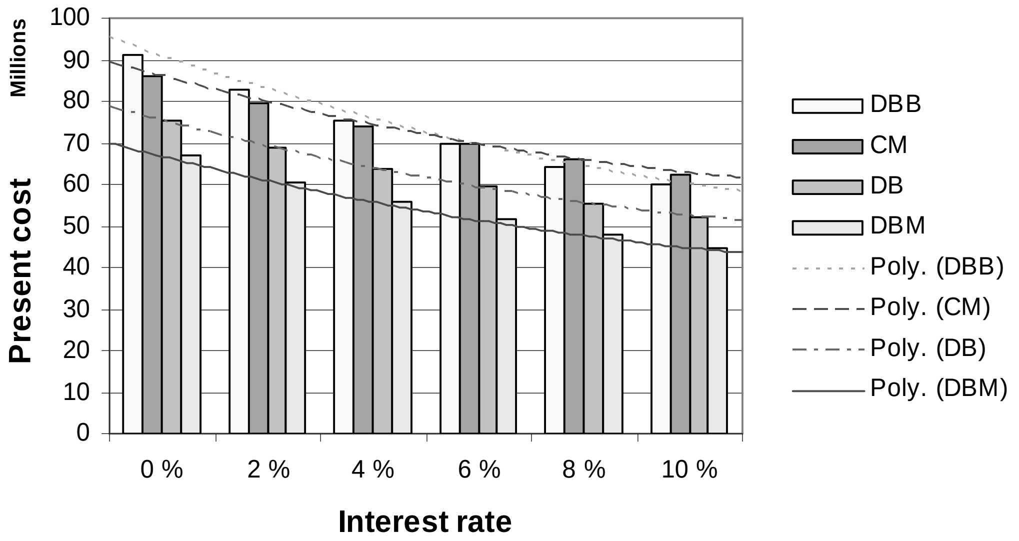

Figure 1. Costs of reference project by different delivery methods and at different discount rates.

The savings from DB and DBM depend on many factors; the most significant one appears to be savings in construction costs. Moreover, the methods also lower a project's supervision, project management and design costs. On the other hand, the savings in maintenance costs appear to have little effect on the present value of total project costs. The present cost is also affected by the discount rate, but – with the exception of relative position of DBB and CM – changes in it do not alter the ranking of the delivery methods. Subsequent assessments were made using relative costs based on a discount rate of 6 per cent.

5. Added Value through Integrated Services

Not only does the cost behaviour of procurement methods vary, their ability to generate value for the client and the other parties also varies. The value criteria generally used were grouped in the study into the value factors of Fig. 2: cost certainty, time certainty, short cycle times, good quality (aesthetics, travelling comfort, minor need of maintenance), safe and environment-friendly implementation, flexibility (ease by which client can effect changes), smooth delivery (effective communication, no disputes or claims), public inconvenience (road availability, minimum user disturbances). The interviewees assessed how well these goals were attained by different delivery methods compared to DBB. The viewpoint was mainly that of the client.

In general, the interviewees found that methods where the contractor is responsible for design (DB and DBM) generate more value. The broader the service package, the better the perceived value generation on average. DBB and CM, on the other hand, were believed to lead to an increased number of interfaces between the parties and possibly to problems, inefficiency and lower value generation. CM was, however, considered superior to DBB in some areas.

Different clients and projects may emphasise value factors quite differently. If flexibility becomes the determining criterion, DBB and CM are the best methods. On the other hand, if the weight of quality and flexibility trebles, the value generation of DBB exceeds that of DB. If again, the weights of flexibility and time certainty increase 2.5-fold, CM generates more value than DB. Yet, as the study focussed on a so-called average project, various value factors were assigned equal weight in drawing conclusions and the illustration of results.

When value generation was studied from the viewpoints of other project parties, contractors and designers were found to have noticed some problems also with the more integrated methods. Contractors perceived high tender costs and cooperation with the designer the biggest problems. Risk allocation and increasing project sizes also provoked discussion. Typically contractors did, however, find that broader service packages lead to efficiency and better possibilities of developing operations. Designers saw problems especially in the implementation of DB where they are often subordinated to the contractor as the limited economic resources of designers seldom give them an equal footing.

Figure 2. Value generation capacity of different procurement methods compared to DBB.

6. Economic Efficiency is the Key

There is a continuous demand on public clients to get more value for tax money. The accrual of costs or value generation in themselves do not prove the excellence of a delivery method in that context. The significant factor is the amount of value the method can generate in relation to its costs. That is why the concept of economic efficiency (EE) was introduced into the study. It indicates the normative ratio of generated value to costs in comparison to DBB.

The conducted analysis and Fig. 3 in the next chapter show that CM's economic efficiency is on a par with DBB. DB improves EE significantly: it generally allows generating more value for the client at lower costs. DBM as much as doubles the benefits of DB and thus gives the best value for money. The total differences are so large that moderate changes in the weights of value factors play no role in the ranking of delivery methods. The overall assessments requested of interviewees concerning the "value for money" of various methods were also in line with the above analysis. The general reasons perceived to contribute to the superiority of DB and DBM included transfer of risk to the private sector, the optimised delivery process and quality as well as utilisation of the management skills of the private sector.

7. Development is the Basis of Future Performance

The study also attempts to provide answers for the long term instead of just evaluating the "historical performance" of delivery methods. Therefore, the interviewees were asked to assess the development potential of different methods. Development potential was divided into more easily assessable sub-factors by main categories as follows: 1) adaptability/regeneration of process, 2) generation/utilisation of information, 3) project team coherence/capacity for cooperation, and 4) means and possibilities of improving workability of delivery method. The first three categories represent general preconditions for development of the activity over the long term. The fourth one covers the concrete means for improving the efficiency of delivery methods presented by interviewees and literature. Based on the assessments of the interviewees and on the critical analysis, it became evident that DBB and CM have little development potential whereas the potential of DB and DBM is significant. The relative development potentials of different delivery methods are indicated by the lengths of the arrows in Fig. 3. However, here the lengths of the arrows are meaningful only in relation to each other, not as exact numeric values.

Future performance is the sum of present performance and development potential. Thus, there are good grounds to assume that the performance gap between DBB and CM on the one hand, and the more integrated DB and DBM on the other, will only widen in the future.

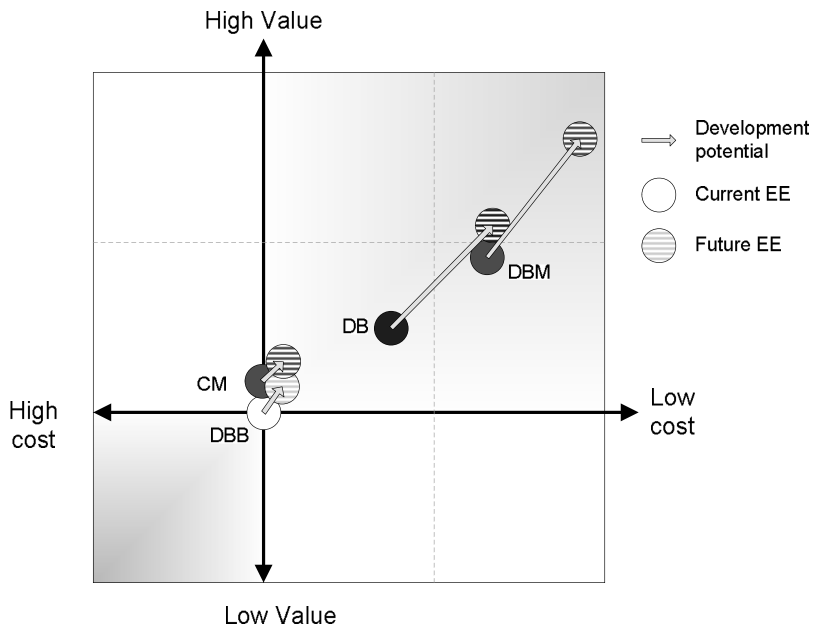

Figure 3. Current economic efficiency of delivery methods and its future development.

Attainment of the full performance capacity of delivery methods naturally requires elimination of the existing factors that limit efficiency. The research report [2] specified the improvement proposals already considered as development potential above. Their aim is to optimise the performance of delivery methods from the viewpoint of all parties (see [1]). In DBB, for instance, the constructability of designs and cost certainty can be improved. In CM, the overlapping of operations can be reduced thereby making project management more effective. In DB, tender costs can be cut, cooperation between suppliers improved, risk allocation optimised, opportunities to innovate increased and quality improved. In DBM, tender costs can be reduced, risk allocation optimised, innovation promoted and flexibility increased.

8. The Future Operating Environment

The future will bring changes also to the operating environment where roads are procured and built. Changes will affect factors guiding procurement (rules, financing, changing traffic environment) as well as the production process – even the end product. In light of the anticipated changes it would appear that more integrated delivery methods will allow us to adapt better to changes than more traditional methods. Yet, there would appear to be no serious hindrances to the use of any of the methods in the future.

9. Application Areas of Different Delivery Methods

The study would seem to indicate that more integrated delivery methods provide better value for money than traditional ones. Each delivery method does, however, have its distinct best applications outside of which its advantages cannot be realised in full. According to Fig. 4, DBB is still suitable for small and simple projects, which offer little room for innovation, or which involve many factors of uncertainty due to parties or issues external to the project. CM, again, is well suited for large and/or tight-scheduled projects involving many constraining factors where the client also must effect changes during implementation or the life cycle.

As project size and degree of freedom increase, DB and DBM become more preferable. Since DBM is suited for larger-than-average projects, DB can be considered appropriate for average projects. DB and DBM projects must not, however, involve factors of uncertainty due to third parties.

10. More Integrated Service Packages for Future Roads

The study clearly indicated that more integrated service packages can provide concrete benefits to all parties compared to DBB. Thus, further development of DB and its adoption as the standard alternative to DBB is recommended. The benefits of DBM are also apparent; it is generally the best solution for large projects.

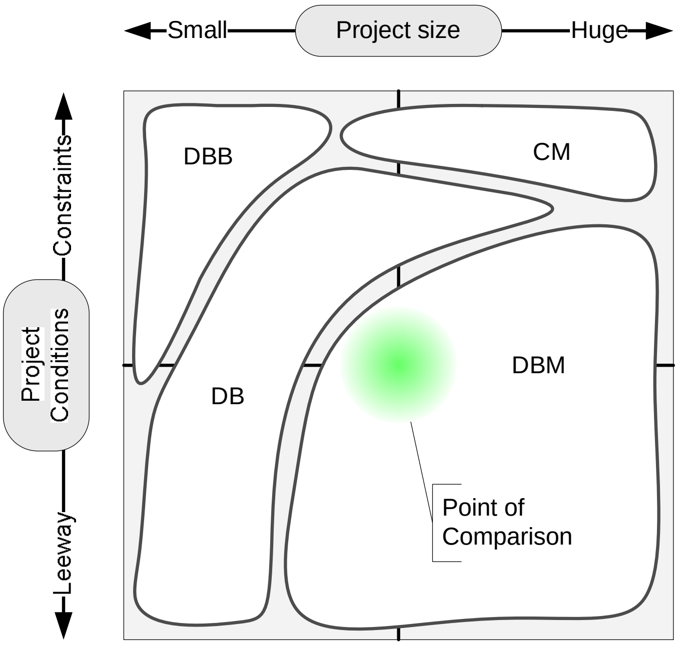

Figure 4. Optimal application areas of various delivery methods.

Changes in procurement must yet occur in steps in order to give industry time to adapt and to allow time for contract standardisation and development of appropriate specifications. Selected delivery methods must also be used continuously to motivate people to acquire the know-how required by new methods which will also make them better. The private sector must at the same time focus on relationship-building and developing cooperation models. Thereby road procurement and implementation can be raised to a new level which furthers the attainment of the client's goals, increases industry's productivity and profitability, and gives society the best possible value for tax money.

It should be kept in mind that the study targeted only road projects. Thus, the results cannot be assumed to be directly applicable to vertical, or even other infrastructure construction, since these often differ from road construction in many ways.

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Advanced Design Management as Part of Construction Management (CM)

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Abstract

Construction management (CM) contracts are increasingly used in large building projects in Finland. It is understandable that opinions on the relevance of CM forms of contracts vary widely. Finnish owners have had mainly positive but also some negative experiences with their CM projects. Typically, many owners are starting their building investments before users are known or users are not yet ready to determine their design requirements. CM contracts make it possible to start new buildings before even room layouts are designed. It has not been easy to change the traditional culture of the sequential design and construction to the concurrent CM culture. The greatest problems lie inherent in the delivery and the contents of the building design documents. The suggested design management model (FINSuke) enables true teamwork between project actors. The results of the initial tests suggest that there are many advantages in CM projects compared to fixed-price projects. For example, it is possible to arrange enough time for designers in the working drawing phase. Designers may now protect the visual and technical solutions without drawing and specifying all the details before the tendering of subcontracts. In addition, it is possible to utilize the solutions of product suppliers. Final designs can be developed in cooperation among a CM manager, designers, and suppliers before the assignment of subcontract agreements. The best performing contractor (or supplier) is then chosen in competitive terms.

Keywords: Buildings, construction management, design management, Finland, project delivery methods

1. Introduction

Herein, a new model (FinSUKE) for managing building design processes as part of construction management (CM) projects is introduced briefly. The FinSUKE model is being developed within the unit of Construction Economics and Management (TKK/CEM) at the Helsinki University of Technology. The FinSUKE study as a whole aims at developing **a new design management system** which will in part ensure the attainment of the project-specific (or building-specific) objectives in terms of performance, quality, costs, and schedule. In part, a few existing concepts such as the basic principles of open building [e.g. 1, 2] have been applied to this model design task.

The design management is herein approached in terms of **planning and controlling** the delivery of the design documents and the procurement concurrently as follows. In general, the two kinds of problems beset conventional engineering, i.e. weak process and weak co-operation [3, 4]. The separation of design and construction has long been presented as **the root problem of construction**. This separation threatens, in particular, the constructability of the building in question. Thus, it is no wonder that great expectations have been attached to the use of design-build contracts, where these two stages are integrated at the outset [3]. However, many empirical findings [5,6] have revealed that the design-build contract alone does not produce significantly better results than conventional procurement methods.

In the manufacturing management literature, push and pull are distinguished as the two primary techniques for managing work flows [7,8]. When the pull technique is used, a site will “shout for” design documents from designers. When the push technique is used, design documents are prepared and submitted to a site according to a design schedule. Herein, experiences have proved that no single model functions well alone. For example, a design schedule cannot be effectively derived from a procurement schedule. This is due to a fact that each of separate bidding packages is only a small, “wrong” piece from the point of view of the design process. In the FinSUKE model, the design management is perceived as **a combination of a push technique and a pull technique** (Figure 1). From the beginning, design management is a push technique until the inspections of the advancement of the design package take place. After each inspection, the remaining management of the work drawings and the specifications is a pull technique which utilized by management at a site.

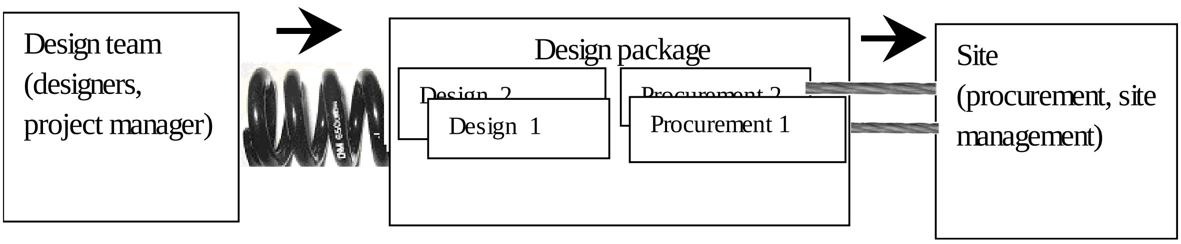

Figure 1: Building design management as a combination of the push and pull techniques.

In many countries, the dominant project delivery methods involve the ones where all the design documents are ready before construction works actually begin. Typically, these practices have been justified by such reasons as pre-managing the complete design process efficiently. On the contrary, the authors counter-argue herein that **the dependencies caused by contract forms and building design must be cut off**. Under CM contracts, the dependencies caused by the contract form are being readily eliminated. But a CM form as a delivery method does not alone guarantee flexible projects. The flexibility has to be carried into subcontracts, especially into building services (M&E) contracts.

From the design management view, **the principles of open building** offer one plausible way to produce highly flexible building (sub)solutions [1, 2]. The cutting of the dependencies not only enables the shortening of the total implementation period, but it has many other advantages. A design team is guided to approach the design of a permanent support with a long life span in a way that differs from the one adopted for the design of an infill part with a short life span. Flexible designs and technical solutions are being enhanced. The principle of cutting dependencies makes also the work of a structural engineer easier because the information such as the loads of the structures and the flues for building services (M&E) are produced on time.

The paper is structured as follows. Next, the founding differences in the use of the contract forms are emphasized in the case of Finland, the UK, and the USA. Thereafter, the three alternative process models of a CM project are introduced. The concept of design packages is introduced as the core of the advanced design management under CM projects.

2. Use of Contract Forms in Finland, the UK, and the US

In Finland, building projects have traditionally been executed under so called **main contract forms**, i.e. general lump sum contracts. A project can be delivered under one main general contract or multiple prime contracts for structural works as well as air conditioning, piping, electrical, automation, and IT installations. When **multiple prime contracts** are used, all the contracts are assigned to the main contractor for coordination only. It is much like the UK nomination system. In Finland, it is normal for owners to hire a professional construction manager (an agent or a representative), who will manage both the design process and the prime contracts. Thus, these main contracts with multiple assigned prime contracts are not considered to be a CM form of contract. In the USA and the UK, construction management with a single general contractor is one of CM forms [9]

In forms of general contracts or main contracts, owners (clients) receive fixed prices and schedules. However, their possibilities to influence processes or to make changes during construction stages are limited. Any change in design involves negotiations between a client and a contractor concerning costs and scheduling. The implied lack of competition infers that changes in the late stages can become expensive.

Chains of competition can be compared in the various forms of contracts as illustrated in Figure 2. In lump sum general contracts, chains of competition are very long. Each building-product purchase must pass 3-4 price competitions. It is very difficult to produce high quality through these kinds of elimination processes. An owner has his or her designers finalize the plans, drawings, and specifications that are used as a basis for arranging competitive bidding among interested general contractors. In turn, a general contractor arranges competitive bidding among second-tier subcontractors, and so on. All these competition stages are based on the cheapest products that meet an owner’s requirements. Designers try to avoid a decrease in quality in these competition chains by specifying increasingly detailed product requirements.

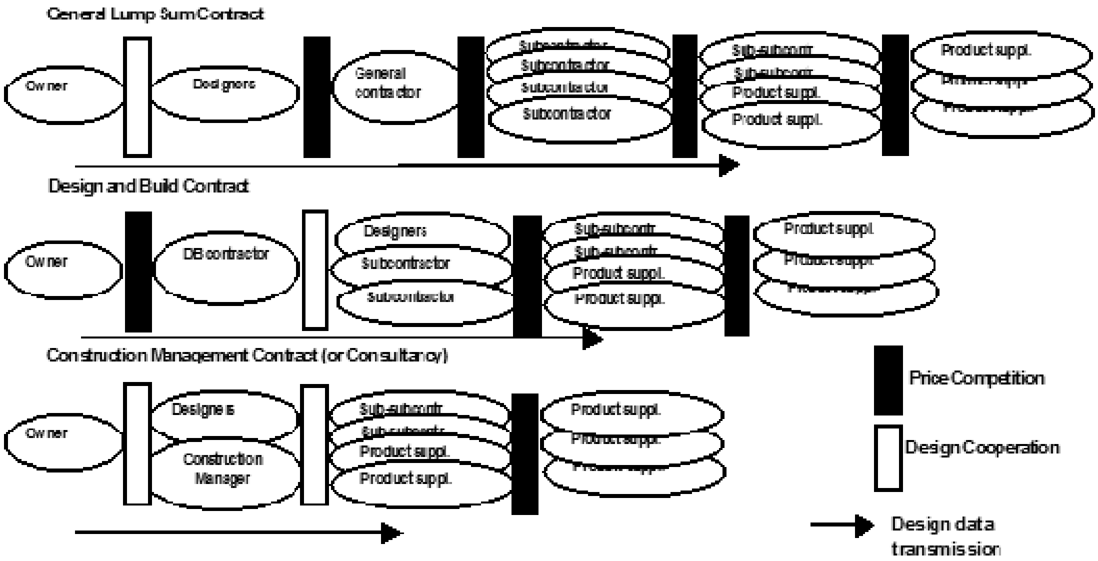

Figure 2: Chains of competition. A comparison of cooperation and price competition in general, design build, and CM forms of contracts [applying 10,11]

Thus, the number of eligible products is reduced and quality/price competition is restricted. All available suitable products and high operational performance cannot be obtained through this low bid chain. Instead, owners are left with many severe low bid problems such as weak quality, chained price competition, decisions made prematurely, and low flexibility for possible design changes [10, 12] When one of the CM forms of contracts is adopted, the improved performance can be part of the selection procedures. In addition, the freedom of suppliers to offer their solutions and assume the responsibility for same can be incorporated into contracts.

The Finnish forms of CM consist of two models as is the case in the USA and the UK, namely, CM consulting (Agency CM or CM for fee) and CM contracting (CM at risk). Construction management is characterized as a form where a professional CM organization leads a project in close cooperation with an owner (client). A construction manager suggests the schedules of the design development packages and those of the procurement packages as well as the related contracts. The relationship between an owner and a construction manager is based on **true cooperation** including open books (cost information). A construction manager acts as an owner's right hand, i.e. their representative who sits at the same side of the table. An owner has the final decision-making power during the course of a project concerning design solutions, trades or works contracts, and suppliers. An owner may make decisions later at more suitable points in time.

The suggested FinSUKE model of design management can be incorporated both into a CM consulting form and a CM contracting form. Likewise, many of its principles are readily applicable to design management contexts where other project delivery methods are used.

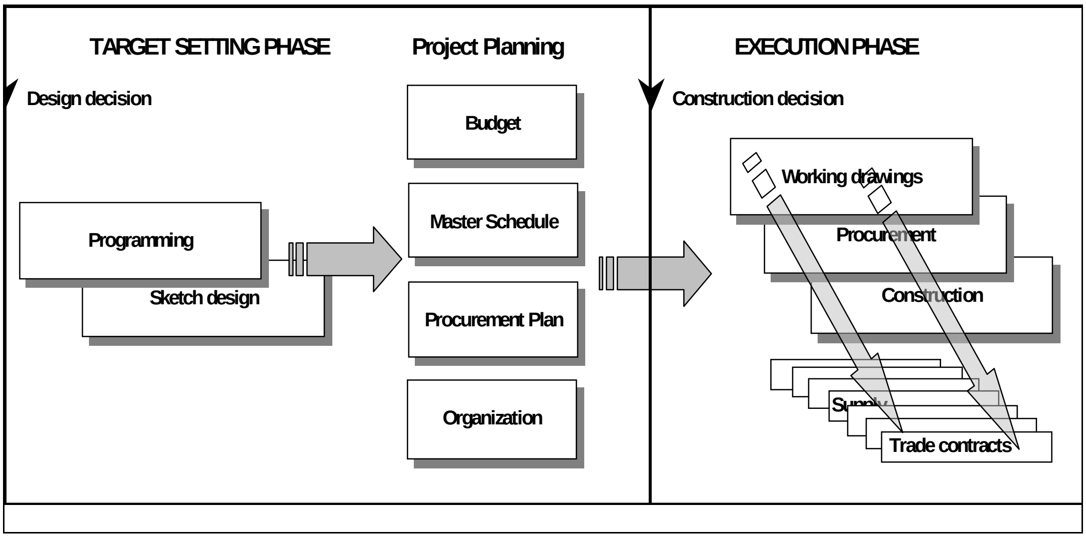

Figure 3: Two-phase model of a construction management (CM) project [12]

3. Three Basic Process Models of a CM Project

In general, a project process is defined to include building design, procurement, and construction works as well as to expose the overlapping of these phases. Herein, **the three alternative basic models** of a project process are illustrated in Figure 4. The critical paths are marked with the shadowed lines. The same (maximum) period of time can be allocated for the actual construction works. **The chain model** is underlying the traditional main contracts, i.e. each sub-process follows fully one another. **The concurrent CM model** involves the time compression based on the two start-ups with the shortest periods that are interrelated, i.e. (a) “Scaling WD1”, which is a period needed to make design documents before the first related procurement, and (b) “Scaling P1”, which is a period needed to make the first procurement before the related building work starts at the site.

The Finnish CM model is designed as a concurrent model, in which the building design, the procurement, and the construction works overlap and particular bidding packages are used as the tools for project management. The durations for making the last working drawings are fairly open to the end.

A physical segmentation adds value also in CM-projects. Using the segmentation it is possible to make design documents ready for one segment while the design of other blocks continues. A segment is usually a vertically sliced entity from a cellar to a roof in new buildings. In addition, the horizontal dimension is applicable in many renovation projects.

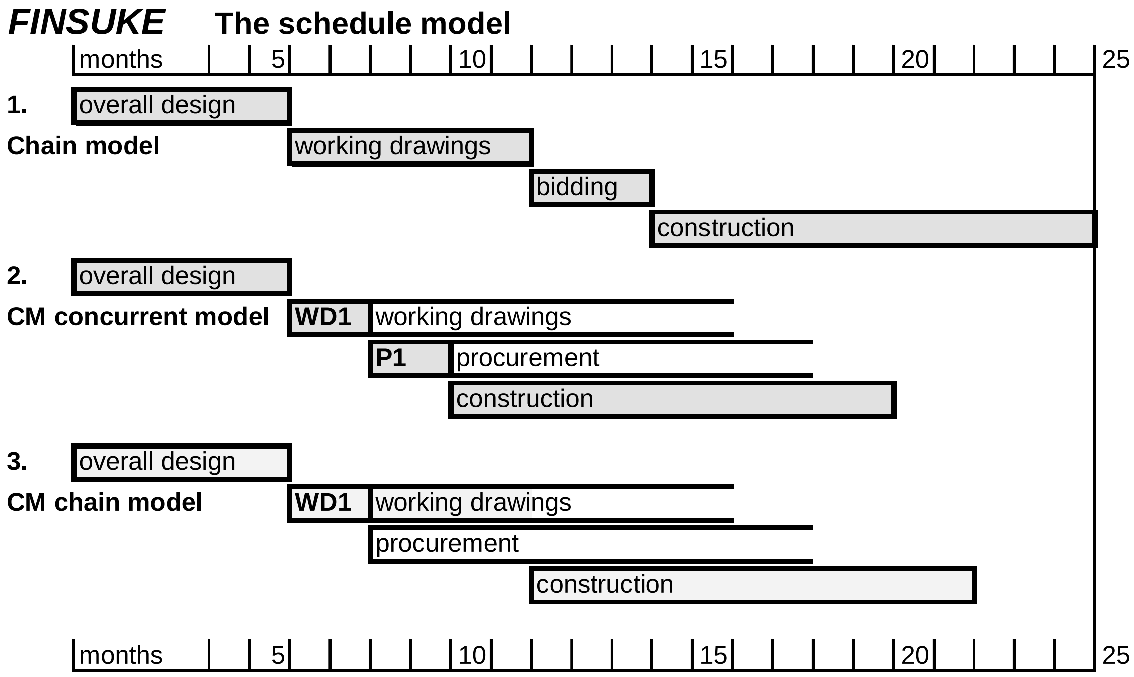

Figure 4: Three alternative project process models illustrated in the case of a typical new building (of 50 000 sqf) in Finland.

4. Design Packages as the Core of FinSUKE model

Under traditional main contract forms, the working drawing phase is often scheduled as one long task (line). Under CM contract forms, the design development is traditionally divided and scheduled based on the project breakdown as **a set of procurement packages**. However, procurement packages are mainly based on trades and so a single procurement package is seldom the most relevant criterion for managing a building design process effectively. Sub-design objects are mostly building elements. Thus, most procurement packages do not contain the complete sets of the enabling sub-designs. This fragmentation of design work causes problems for the delivery of design documents. For example, when only one set of design documents for a procurement package is suddenly needed, the designer must ad hoc solve the related design package as a whole. In the same vein, when the building works are compiled into packages purely by trades, this implies the fixing of many preceding sub-designs too early (concerning e.g. metal works, masonry works).

When the design management is acknowledged as one of the primary, interrelated processes, separate design tasks and documents are compiled into sub-designs based on the concentrations of the primary dependencies among the design tasks themselves. In the suggested FinSUKE model, these sub-designs are managed and called as **design packages**. The model includes a list of standardized design packages with their basic contents.

Table 1.@b@1@e@1 FinSUKE standard design packages, building services (M&E) is not included. Based on Finnish Building 2000 BE classification (translated using UNIFORMAT II) @b@6pr

	Design package		Design package
0	The supplementing design documents	8	Space partitions and doors
1	Excavation works	9	Spacial components
2	Demolition works	10	Other space structures
3	Foundations and slab on grade	11	Interior finishes
4	Elevetors	12	Fittings (to be renoved)
5	Frame	13	Fittings (new)
6	Enclosure	14	Space equipment
7	Roofing	15	Site

In each CM project, **design packages** are determined early as part of a project plan. A CM team compiles and schedules a set of the most effective design packages in cooperation with the designers. The design work is divided on a basis of the standard design packages. Optimally, each project-specific design package includes those parts and works which are procured at the same time and produced accordingly through the preceding design tasks (Figure 5).

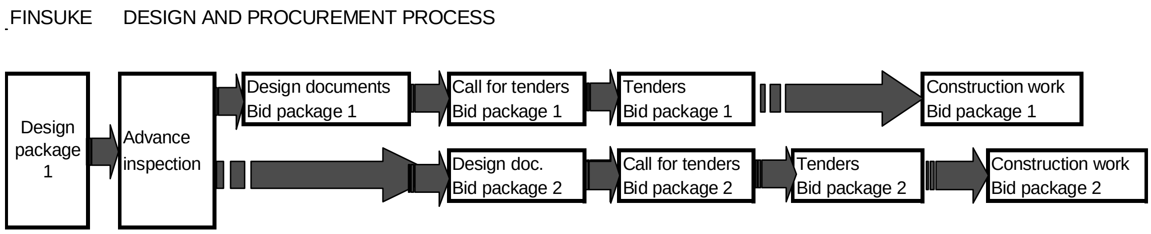

Figure 5. Management of a building design from the design package to its use as a basis for the procurement phase and the construction phase (FinSUKE).

The use of design packages enables **the design team** to achieve many advantages such as:

- To avoid the accumulation of the design work (traditionally scheduled as one task) to the last remaining days through the introduction of design phasing.
- To facilitate effective communication among the designers as well as between the owner and the design team and the procurement team.
- To balance the need and use of design capacity and to enable the flexible increase of the design resources when needed.
- To avoid the preparation of non-constructable sub-designs for single procurement packages.
- To avoid the non-productive preparation of design documents with too small scopes.

- To allow more time, overall, for the attainment of the key objectives of the building design such as functionality, safety, environmental conformance, and aesthetics.

In addition, the use of design packages enables **the procurement team** to achieve several advantages such as:

- To integrate two or more initial design packages to support bigger procurement packages, when this is justified.
- To prepare all the documents of one design package effectively and later to phase the submission of the finished documents according to the related smaller procurement packages.
- To initiate the procurement of a certain package without the need to prepare and submit all the related design documents at the same time.

At the project level, the use of design packages enables **the project management** to achieve the key advantages such as:

- To allow the beginning of the construction work also in the case when all the related design documents are not ready.
- To leave more (enough) time for decision making, especially concerning the final infill of the building.
- To enable the control of the design process and the real-time feedback to the sub-designs.
- To inspect each design package in advance will prevent typical design errors from occurring.

In the FinSUKE model, **a design schedule** is prepared by design packages also in the cases when construction works would not begin before the completion of the design

In the design documents (packages), **a breakdown into the procurement packages** need not to be readily presented . In turn, a CM team determines the contents of each procurement package after the completion of the related design packages. A CM team prepares the tender documents where the contents is specified (often in more detail than in the related design documents) for the procurement. However, some of the traditional trade divisions (e.g. the masonry works for the facade/interior and the steel works) needs to be broken down into parts.

In turn, **a procurement schedule** is prepared by using and integrating the design packages (Figure 6). This is so because the common language is needed in order to ensure the seamless interfaces between the site staff and the designers. Thus, both the design documents and the tender documents are assembled by the design packages.

DRAWINGS	DESIGN PACKAGE	BID PACKAGES
Cut-away drawings Details Balcony Windows and outer doors diagrammatic documents	**6 THE FASADE** Fasades, outer doors, windows Fasade equipments Balcony, canopy	Fasade timber work Fasade claddings Fasade equipments Flashing Windows Outer doors Painting Balconies

Figure 6. Design package as a linkage between design documents and procurement breakdown.

In the FinSUKE model, all the design documents are drafted and finalized up to the working drawings that enable the actual procurement. The exceptions are stated in a project plan.

In CM projects, **the completion degrees of design documents for a procurement package** may vary In each case, the selected procurement strategy determines the required completion degree. Readily, there are (at least) the three alternative procurement strategies as follows:

- Bidding based on working drawings
- Bidding based on tentative design documents
- Bidding based on design requirements.

In the design schedule of a CM project, the allocation of time takes place at a level which allows to present (a) the preparation periods for the design packages, (b) the dates for the pre-inspections of the design packages, (c) the dates for the uses of the design packages, and (d) the dates for the uses of the working drawings for the procurement packages.

5. Conclusions

In traditional building projects in Finland, all the decisions are made in the beginning of the design process. The easy-way-out attempts are being made to fix the final layout of the spaces and to specify the products by dictating these decisions prematurely. After the prolonged project process, the spaces have become readily outdated and, as usual, any changes would turn out to be expensive Normally, designers specify all building products in detail. When a contractor has been buying these detailed products, the prices have risen to too a high level; while other suppliers offer cheaper products which have same or even better properties.

The suggested FinSUKE model is designed in order to change the aforementioned ineffective procedures. The permanent support (shell and core) of the building will be designed first so that it will meet the demands of the modifiable infill. The detailed solutions of the spaces (infill) are finalized according to the space-specific decisions; taking also into account the choices of the tenants. For a procurement phase, design documents can be prepared well to comply with each of the “chosen” products. During the negotiations, a procurement team (i.e. procurers, project manager, and designers) reviews upon how the alternative solutions influence the final outcome. If the other solution is chosen, the original product will be replaced.

Standard design packages fit the construction of new buildings. Instead, the effective adoption of CM forms is more demanding in the case of renovation projects and in building services (M&E) works. For example, the management of M&E design programs is problematic due to sub-wholes based on each of the spaces (or interior areas).

In the FinSUKE model, the design management is theoretically defined as **a combination of a push technique and a pull technique**, i.e. as a push technique up to the completion of the design package and, thereafter, as a pull technique performed by the site management. The site team secures the status of the design documents for 4-6 weeks ahead. A tool like The Last Planner [13] seems to be effective for the pull-based control at site. In addition, **the principles of open building and the principal procurement strategies** are being incorporated into the later versions of the FinSUKE model.

The testing of the design packages and the other FinSUKE tools will continue up to the year 2006. So far, the parts of the model have been mainly tested retrospectively. The testing of FinSUKE model prospectively will also be carried out. In particular, the ways of managing building services (M&E) design process need to be enhanced further.

In Finland, **the scope of design work and design management tasks** are described with standard task lists published by the Building Information Foundation RTS [14]. The standard task lists are prepared for the main contract forms. Such task lists do not at all support the active participation of the designers in the procurement process and the construction process. The TKK/CEM research team is preparing the lists of additional tasks as part of the FinSUKE model.

Finally, the authors do not believe that, in building projects, one can succeed by trying to attain the set objectives by drawing up the more exact descriptions of the tasks of the various project actors and arranging the low-bid competitions for the accomplishment of the detailed tasks. In turn, **the authors recommend performance based methods** for selecting CM consultants, designers, CM contractors, and subcontractors [see 15, 16] .

The suggested FinSUKE model promotes and creates procedures and methods to improve the cooperation among the parties in the construction project. The essential tool to increase the cooperation is a project plan in which the design packages are integrated. Furthermore, the advance inspections of the design packages and the contract negotiations promote cooperation. The constructability is secured at the negotiations during the selection of subcontractors. It is possible to buy product know-how from the suppliers and it is possible to transfer responsibilities for the products to their actual experts – to subcontractors and suppliers. The best performing contractor (or supplier) is then chosen. In CM projects, it is possible to have enough time for this cooperative design development during procurement process.

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Advancing Building in Finland through Special Systems Contracting (SSC)

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Abstract

In Finland, the Special Systems Contracting (SSC) refers to the design, manufacturing, delivery and installing of the building elements by various Specialty Contractors (SCs). A call for SSC tenders includes readily the schematic design documents with the functional and technical requirements. A contractor is responsible for his system element in question and its interfaces with the other building elements as well as the performance of design solutions. Through the SSC, a true know-how and quality competition or a life-cycle delivery competition can be arranged. Essentially, the know-how of both designers and the SCs is fully utilized within the suggested SSC model. Traditional suppliers and subcontractors can adopt herein a new enlarged role with incentives for system development, innovations, and new delivery packages. The penetration of the SSC will create more effective networking within the building industry. In the on-going study, the first retrospective case projects have been analysed. The prospective testing in the actual projects will follow.

Keywords: Special systems contracting (SSC), specialty contractor (SC), design documents, procurement, Finland.

1. Introduction

1.1 Background and Objective

In Finland, the use of the alternative contract forms has been quite stable during the last years. Normally, an owner relies on a general contractor and some technical prime contractors with fixed prices. Finnish designers are accomplishing computer aided design with modern tools. However**,** the use of design documents as part of call for tenders has remained the same. All design documents are completed before calling for tenders and the competition between contractors is based on the efficiency of construction.

In the design and build (DB) method, general contractors can utilize fully their expertise in project management. In turn, the know-how of systems and products among subcontractors can be utilized through the suggested special systems contracting (SSC) model.

The SSC refers to the design, manufacturing, delivery, and installing of the building elements by various specialty contractors (SCs). A call for SSC tenders includes readily the schematic design documents with the functional and technical requirements. A constructor is responsible for his system element in question and its interfaces with the other building elements as well as the performance of design solutions. Through the SSC, a true know-how and quality competition or a life-cycle delivery competition can be arranged. Essentially, the know-how of both designers and the SCs can be fully utilized. On the other hand, the interfaces of separate deliveries are still problematic in the current uses of the SSC in the building sectors in Finland. Likewise, the responsibilities of designers is not yet well-thought out. A lot of know-how and work is required from all the project parties. The negotiations for an agreement as well as the conditions of these agreements are complex. In addition, the future penetration of the SSC seems to involve a risk that number of suppliers and competition among them might decrease.

This paper is based on the ongoing study project for **a new model (FinSUKE)** for managing building design processes as part of construction management (CM) projects in Finland [1, 2]. The FinSUKE model is being developed within the unit of Construction Economics and Management (TKK/CEM) at the Helsinki University of Technology. The study as a whole aims at developing a new design management system, which will in part ensure the attainment of the project-specific (or building-specific) objectives in terms of performance, quality, costs, and schedule [1].

The main objective of this paper is to introduce the initial special systems contracting (SSC) model, which is in part based on the analysis of some retrospective case projects, as follows.

1.2 Specialty Contractors in the USA

Herein, the definition of specialty contractors in the US context [3] is reviewed in order to offer a benchmark for understanding the Finnish SSC approach also outside Finland as follows.

In the US context, specialty contractors (SCs) are generally construction's 'job shops'. SCs allocate their resources to match various 'delivery' dates demanded by multiple projects. Further, specialty contractor management depends on the quality of production management on projects, i.e., their coordination by general contractors. SCs perform the construction work that requires skilled labour from one or at most a few specific trades (e.g. electrical, plumbing, HVAC, roofing, iron work, and concrete) and for which they have acquired special-purpose tools and equipment as well as process know-how. Because of this specialization, their work is limited in scope relative to the work required to complete an entire facility [3].

Further, **subcontractor activity** not only pertains to construction work on site, but, out of necessity, also to work related to design completion. Indeed, it is seldom the case that contract documents, including design drawings and specifications, are unambiguous and sufficiently detailed to be of direct use to specialty contractors. Shop-drawing detailing followed by architect-engineer (AE) approval is often expected of specialty contractors, but this process more often than not reveals incompatibilities in the design documents that are presented to them and vagueness in their scope of work… It must therefore be acknowledged that the involvement of the contractor and subcontractors in the project begins, not with the start of construction, but with completing the design [3].

1.3 Special Systems Contracting in Finland

In Finland, the special systems contracting (SSC) model in building is defined as a contract in which a supplier takes the responsibility for the system design and detailed engineering, manufacturing, and installation of the building element in question including the in-use-performance of the system as defined by the owner (client). The SSC transfers a part of design responsibility to the system contractor and it also combines the product design and production planning [4, 5]. When competition is based on both design solutions, material choices and production efficiency, the SSC model does not discriminate construction techniques and materials. Competition expands from the production know-how to the system know-how and from the details to the wholeness. In competing with solutions, it is possible for system contractors to achieve more innovations and develop their production. In the SSC, it is possible to compete only based on production technologies but competition can include a system and technical solutions, too.

In comparison, special system contractors are responsible for wider scope of work in Finland than traditional specialty contractors in the USA. The latter are mainly interested in the design phase of the products, but Finnish special system contractors are actually responsible for designing their systems, too.

2. Methods and Forms for Special Systems Contracting

2.1 Key Principles in the FinSUKE Development Project

The principles of the FinSUKE model are presented in Kiiras and Kruus [1]. Herein, the key principles are introduced only briefly as follows.

In the FinSUKE model, **building design management** is perceived as a combination of a push technique and a pull technique. From the beginning, design management is a push technique until the inspections of the advancement of the design package take place. After each inspection, the remaining management of work drawings and specifications is a pull technique which is utilized by management at a site. [1]

From the design management view, the principles of open building [6] offer one plausible way to produce highly flexible building solutions. A design team is guided to approach the design of permanent support with a long life span in a way that differs from the one adopted for the design of an infill part with a short life span.

2.2 Special Systems Contracting as Part of a Building Project

The special systems contracting as part of a construction process is shown in Figure 1.

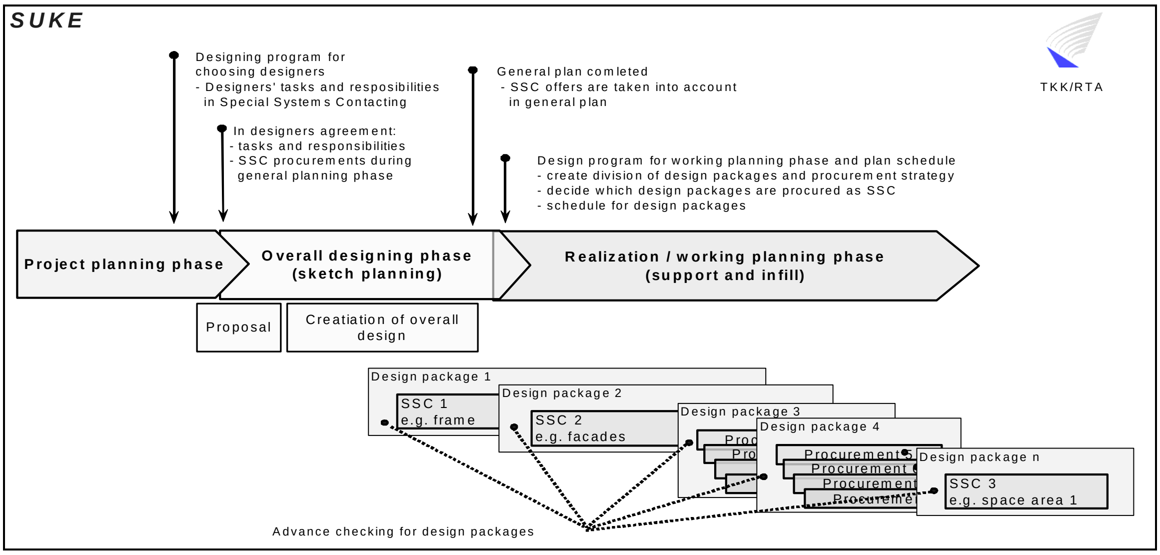

Figure 1. Special systems contracting (SSC) as part of construction process (FinSUKE).

In the beginning of **the overall design phase**, the project management (team) will draw up the design programme for the choice of designers. In the design programme, the designers' tasks for the SSC procurement are defined. The same tasks are presented also in design agreements (i.e. the content, the scope and the schedule of the procurement and the requirements to the accuracy of tender documents).

The design documents for the SSC procurement, which have been completed during the overall design phase, are also taken into account when making an overall design. At the end of the overall design phase, the inspection is performed. Project management draws up the design programme for the working drawings based on the overall design. A project plan shall include a division of design packages and a design schedule and it also identifies readily the particular design packages to be procured through the SSC procedure.

The design documents within the calls for tenders are later taken into account in other design packages. Furthermore, the special system contracts are scheduled in a way that allows, if necessary, the adoption of normal procurements. **A design package** for a special system contract is presented only with requirements and specifications, unless the project management instructs designers otherwise. In the FinSUKE model, only the independent building elements, which are designed as one design package, can be procured as a special system contract. Thus, the model emphasises the shared design and the enlarged responsibility of a contractor. At the same time, the aim is to emphasise the position of the architect and the duty of specialized engineers for checking and combining the separate designs (documents).

2.3 Process of a Single Special System Contract

The main design tasks of a single special system contract are presented in Figure 2.

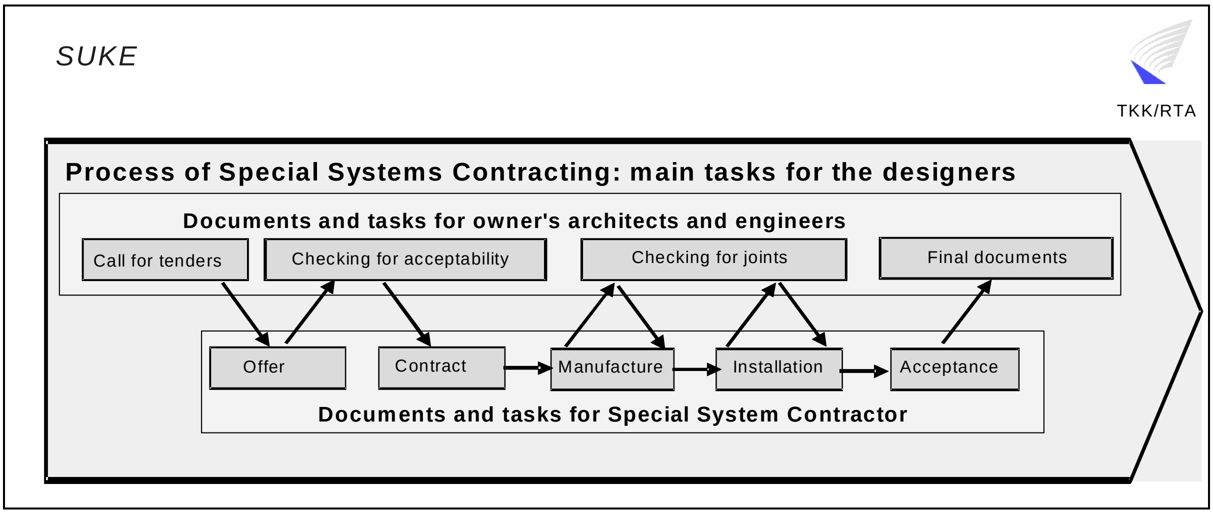

Figure 2. Process description of the special systems contracting (SSC) (FinSUKE).

In the SSC, the main tasks of an owner's architect and engineers are defined as follows:

1. **Create the design documents for the invitation for SSC tenders**
A designer drafts the documents of the call for SSC tenders (the requirements, sketches, instructions etc.) and participates in the preparation of commercial documents. In the preliminary examination of each design package, the definitions and the requirements based on the extensions of the coupled building elements are stated.

2. **Inspect the acceptability of the offered designs**
A designer checks the acceptability of the tender design of each Special System (SS) contractor and performs the comparison of the accepted tender designs.

3. **Participate in the procurement negotiations and the agreement preparation**
An owner's designers participate in the procurement negotiations directing the contractor's design work. A SS contractor's designs are developed into the final level before the signing of the agreement. Thereafter, the solutions of the SS contracts are integrated within an owner's master design and the designs are revised and accepted.

4. **Inspect the production plans of the special system contractor**

An owner's designer checks the compatibility of each SS contractor's production plans. However, a SS contractor has a responsibility for the contents of production plans, but an owner's designer is responsible for the interfaces.

5. **Participate in the inspection of the installation plans in advance**

An owner's designers participate in the inspection of the installation plans before the beginning of the construction work at site. The checking concerns the conformance with the construction and the interfaces.

6. **Check the as-built documents**

As part of the acceptance inspection, an owner's designer checks the final as-built drawings and documents of the system and places the detailed system drawings to the final design documentation of the project.

In the SSC, the responsibilities of building design must be agreed upon early. These significant design responsibilities are taken into account also in the payment schedule for each SS contractor. There are no contractual agreements between SS contractors; their joint participation on a single project is arranged through general contractor-subcontractor agreements. The role of a general contractor is then to manage also all the activities of SS contractors at site.

2.4 Definition of Systems and System Division in the SSC

An abstraction 'system' is determined as an entity, which is independent from other entities, i.e. building elements [4, 5]. The definitions for the term system in the SSC model vary in the literature. At its widest, a system contains the whole building as an individual system. At its smallest, a system includes only, for example, the mounting and planning of a small part of construction work, like concrete reinforcing.

In the FinSUKE model, the SSC is limited to refer only to larger systems where a SS contractor is responsible for the system design, the production planning, and the installation as a functional element of the building in question. The SSC is also limited to refer to entire design packages. A SS contractor's input into the project-specific design of the system element is essential. This differs from the usual CM way of procurement in which a supplier's solutions are included in the final design.

According to the principles of the open building, a building is divided into the systems of the permanent base building (support, shell and core) and the flexible space infills. The flexible space infills are further divided into the interior areas (or departments), the design and the realisation of which are accomplished in accordance with the users' complementary requirements. The fixed spaces are carried out either in connection with the permanent base building or in connection with the flexible spaces (Figure 3).

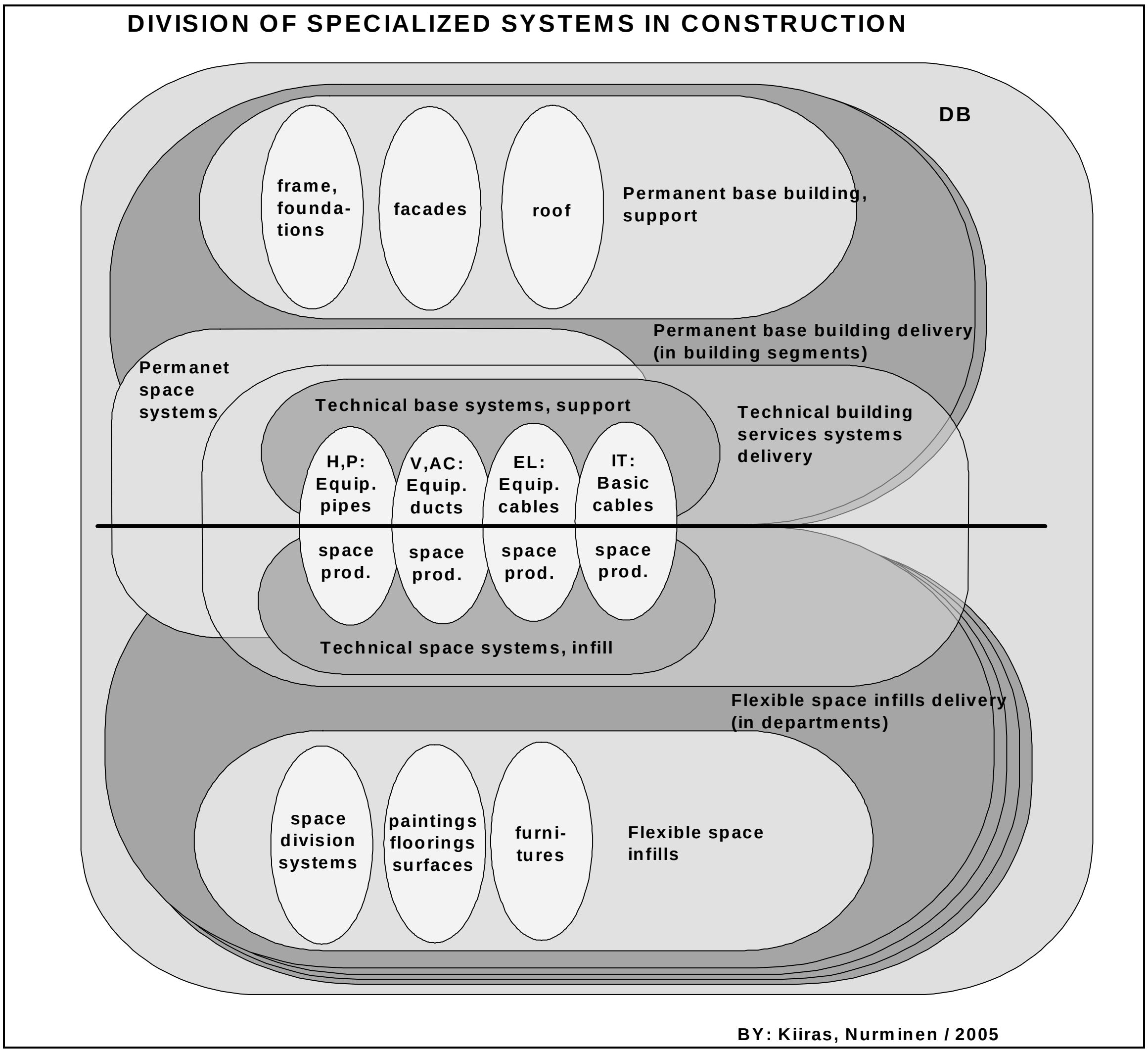

Figure 3. Division of specialized systems in construction (FinSUKE).

Concerning the independence of design and production, the systems are divided **into the five categories:** base building systems, permanent space systems, technical building services systems, flexible space systems and exterior area systems as follows:

- Base building systems (in building segments): ground work and excavations, demolition, foundations and building frame, roof, facades and outer levels,
- Permanent space systems (in building segments): permanent space areas (stairs, entrance halls, auditoriums etc.), space components,
- Technical building services systems: HEVAC systems according to the trades (plumbing, heating, ventilation, cooling, air-conditioning, electricity, information systems etc. separately) **or** technical base systems including central equipment and fixed base system (pipes, ducts and cables) to the border of the interior area (technical core),

- Flexible space systems: separate space areas or departments, HEVAC techniques of the space infills either as their own **or** to be included in the SSC of the space area and
- Exterior area systems: all exterior building area structures, including the HEVAC technical work in the exterior areas.

The SCC of the space infills is carried out by departments, which can be procured as separate units. So the SSC of the space infill contains both the construction and technical design and allows the integration of the production technique with the space parts.

2.5 Design Documents in the SSC Model

In the general FinSUKE model, the three design "as-is" levels are determined for the design documents as part of the call for tenders as follows: 1) final designs according to one solution, 2) "directive" designs or 3) aesthetic, functional and technical requirements. An owner's designers will prepare complete plans according to one solution in design packages, if no other instructions are given [1].

On the basis of the completeness of the design, the invitation for SSC tenders is divided from a level where only the production plans of the system are missing into a level where only needs and requirements are described. According to this "freedom degree" of the design, at the widest each SS contractor is competing on its system and the technical solutions. In addition, the aesthetical, functional and technical requirements as well as the selection criteria are presented in the call for SSC tenders.

In the SSC, a SS contractor's tender design must be at the level of directive design to prove the conformance with the specifications, the quality of the system and the requirements of the regulations. Furthermore, the integration possibilities of the related systems are secured. In each of the SS contractors' agreements, the designs are developed into the level of the final designs.

3. CASE Projects and Research Aims

3.1 Building Projects at the University of Helsinki

The University of Helsinki is the largest university in Finland and its scientific base is wide, 11 schools from medical to law and bioscience. The total amount of the students is about 40 000 and the building area is circa 750 000 m^2. The university and its technical department acts as a client and an owner in building and renovation projects. During the last years, the investments in the construction have been 30-50 million euro yearly.

The CM methods are widely used in the university projects because of the flexibility of the method. In addition, an open building ideology, new construction forms, LCC-competitions, partnership contracts and other new methods are being co-pioneered and tested in the projects and, thereafter, during the facility management carried out by University of Helsinki. In the future, one of the aims is to utilize more SSC methods in building projects.

3.2 Analysis of SSC in Case Pilot Projects

The SSC model has been tested in several case projects and the model (described in section 2) was applied to the actual pilot projects. Herein, the results of the analysis of some case projects at the University of Helsinki are summarized as follows.

Learning centre building at Viikki area (Infocenter, completed 1998)

Test scope: A technical specialty contractor was responsible for the design and the construction of the HVAC system. The energy consumption for the first five years was also a part of the procurement competition. Procurement documents: The invitation for tenders was done by functional and technical requirements. The tenders included directional designs and energy consumption calculations. Results: The new method for call for tenders, own designs from all technical contractors, life cycle costs as competition criteria, and low energy consumption.

Medical laboratory building at Meilahti area (Biomedicum, completed 2000)

Test scope: A contractor was responsible for the design, the manufacture, the delivery and the installation of 20 ventilation plants in engine rooms. The properties and the energy consumption of machines were calculated before the contract and tested after the delivery as the complete units. Procurement documents: The invitation for tenders was done by functional and technical requirements. The tenders included the description on the plant and its properties. Results: Life cycle costs and technical properties as competition criteria, machines tested before installing, high reliability on plants and low energy consumption.

Bioscience laboratory building at Viikki area (Biocentre 3, completed 2001)

Test scope: A general contractor was responsible for the design and the construction of the foundations, the frame, the roof and the facades. A technical specialty contractor was responsible for the design and the construction of the HVAC system and also the energy consumption for the first five years was part of procurement competition. Procurement documents: The invitation for the both tenders was done by the outline drawings completed with the functional and technical requirements. The tenders included the directional plans and in technical system contract also the energy consumption calculations. Results: Five different frame solutions for the same architect's outline drawings, five different HVAC solutions for the same frame drawings, developed building frame system and low energy consumption.

Office and library building at Helsinki City centre (Minerva building, completed 2005)

Test scope: A subcontractor responsible for the design, manufacture, delivery and installation of the steel-framed glass curtain wall. Procurement documents: The invitation for tenders was done by the complete drawings according to one solution. The tenders were asked as the contractor’s own system with the directional plans and the details. No offers were received. The glass wall was divided and procured in smaller trade parts. Results: SS contractors were not interested in such a difficult and small delivery and this influenced also the master construction schedule.

3.3 Research Aims for Prospective Projects

The research underlying this paper is continuing with new prospective projects as an action research method by piloting all the procedures discovered and developed in the former pilot projects. According to the statements in chapter 2, the hypotheses of the case study of the SSC are initially as follows:

- The supplier of the system is responsible for one specific building system,
- A system division corresponds to the design package division of the FinSUKE model.
- The procurement of building area, permanent structures and spaces are separated.
- A building design is divided in the two phases: the overall design and the realisation design (design development and detailed design).
- The documents for call for tenders are based on system requirements.
- Tenders include directive plans and the attention is paid on the following plans.
- The status of an owner's designers is emphasised.
- The guarantee and the service life objectives of each SS contract are determined separately.
- A construction project can be carried out effectively by dividing it into SS contracts.

Some obstacles for the SSC to become common include the indefinite definitions of the design responsibilities as well as the designers' worry of their tasks not being clear. Also a small number of potential suppliers is slowing down the penetration. An attempt is to reduce difficulties by emphasising the significance of the overall design phase, increase the main designers' consolidation obligation, and extend procurement entities.

The future study aims at solving also these problems, which have appeared in the SSC through the advanced design management. Also the hypotheses, the rules, and the methods that have been presented will be tested in future new construction and renovation projects. The performance based procurement and Best Value Procurement [7] will be tested in some case projects, too.

In addition, the international use of similar methods will be reviewed and then compared with this Finnish way of action. With the help of site visits and research co-operation, it is possible to become acquainted with the use of the special contractors in the international field. Thus, both design management and project management will be enhanced with the help of the SSC model.

4. Conclusions

In the suggested Special Systems Contracting (SSC) model, each SS contractor is responsible for the design, the manufacturing, the delivery, and the installation of the separate building elements. Possibilities for quality competitions and competitions for life cycle deliveries and longer guarantees are created. The SSC model makes it possible to manage the project by independent and causally interrelated entities instead of details.

In the FinSUKE model [1], the SSC is limited to refer only to systems, of which the specialty contractor is responsible for the product design, the specific production planning, and the installation of the system to be a functional and independent element of the building. In SSC the project-specific planning work of a system is an essential part of the delivery. According to the principles of the open building [6] the FinSUKE model divides the building into permanent support elements and flexible space elements.

Thus, one of the main aims is to clarify how both the designers' and the suppliers' know-how can be taken into the best use with the effective SSC. In particular, with the simultaneous analysis of design processes in CM projects and the testing in prospective SSC-cases, the instructions for using the SSC model will be developed. The tasks and responsibilities of project actors during the various stages will be clarified.

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Minimizing Elements of Control of a Construction Contractor

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Abstract

Client control over a construction project is an essential element in the delivery of construction. Construction management is a booming profession in the construction industry. The construction industry also has some stubborn problems to which the industry is trying to find solutions. Some of the problems are poor performance (defective construction, not on time, not on budget, and not meeting the intent of the client), a lack of accountability for problems, a lack of continuous improvement, deteriorating quality of design documents, and a lack of qualified personnel entering the industry. This paper hypothesizes that the problems are being caused by a management/business issue. It uses the example of Ricardo Semler and the transformation of SEMCO, a Brazilian based manufacturing company, from an acceptable company to a very efficient, high performance, successful company by minimizing direction, management, and control. Other successful business practices are used to support the thesis of Semler. The paper proposes that the same approach can be used in the construction industry to minimize the current performance issues. The paper proposes that by minimizing management and subjective decision making by all participants and in all relationships, the construction performance issues can be severely minimized.

Keywords: Minimized control, minimized direction, minimized subjective decision making

1. Introduction

The construction industry is characterized by low performance, sharing of accountability, and the maximization of management [2, 7]. Construction projects are not being completed on time, they are not meeting budget, and they are not meeting the expectations of the owners. Owners cannot identify the source of the problem. Identification of the designer as the problem led to the design-build process where the designer works for the contractor. The inability of the design-build process to meet the client's expectations of performance led to the formulation of the construction manager at risk (CM@Risk) delivery process. There is very little empirical to identify what is causing construction nonperformance [1].

Analysis of the Construction Industry Structure chart (Figure 1) gives some possible clues to why the construction industry has had performance issues. The construction industry has historically been awarded based on low price. The price based environment has the following characteristics:

1. The award is made based on price.
2. Risk is minimized by the client's representative through specifications, management and control.
3. Subjective minimum standards are used for requirements.
4. There is no performance information on contractors and construction systems. Therefore there is no method to identify if a system is an "or equal" to what is specified. This becomes a subjective decision.
5. There are relationships, trust, and maximum information passed between the client's representatives and the contractors. This is a result of subjective decision making of the client's representatives.

There are three major actions that maximize risk. The first is that the client is directing the contractor to bid the lowest possible price or maximize the amount of risk on the project. Note that risk and performance are reciprocal. If the contractor tries to use their expertise to minimize risk, their price will rise, and they will be noncompetitive on the project. The contractors are being directed to not minimize risk using their expertise, but maximize the amount of risk by bidding the lowest possible price.

The second action is that the requirement is based on subjective minimum standards which have no proven correlation with performance. If the requirement is not sufficient, the designer is powerless to rectify it because it is a standard. The third action is that the contractor is being told to do minimal work which is based on subjective standards, and to do things as economically as possible. They are being told that any unforeseen condition is not there responsibility. The contractor is being directed to act in their own best interest, and not in the interest of the client.

The price based environment is creating low performance by giving the low performing contractors the competitive advantage. This creates an adversarial environment by directing the contractor that they have no responsibility to act in behalf of the client. The price based environment then uses subjective minimum standards which have no correlation with performance. The environment is therefore: filled with nonperformers, adversarial, and ambiguous. This environment is inefficient and therefore, nonperforming. It is in this environment that the client is attempting to manage and control the contractor.

2. Hypothesis

Management, control, and inspection are not an efficient way to do business. In the manufacturing sector, lean manufacturing and continuous improvement efforts identified that piecemeal work, incentives, and management, inspection, and control of manufacturing workers and their production lines was inefficient and noncompetitive. This paper proposes that to improve construction performance, clients must minimize management, direction, control, and inspection of the construction contractor. Clients must create an environment that motivates the contractor to do quality control.

3. The Transformation of SEMCO

SEMCO is an example that releasing control can increase efficiency, expertise, and performance. Ricardo Semler, the CEO of Brazil-based manufacturing company SEMCO, implemented a formal structure within his company which shifted control of work to employees who performed the work. This example shows how SEMCO thrived using these practices. It is a potential solution for the construction industry to solve performance issues.

The origins of SEMCO were established in 1954 by Antonio Curt Semler, who patented a centrifuge for separating oils, and started the small machine shop called Semler & Company. Within a short while, the company became a $2 million (gross revenue) a year business. Around 1960, the company formed a partnership with two British marine pump manufacturers which transformed SEMCO into the major supplier of the Brazilian ship building industry. As time progressed, Ricardo Semler, son of Antonio, took charge of the company.

After firing two-thirds of his father's senior managers, and after twenty years of changing SEMCO's business practices, the company now has gone from the founders' peak of $4 million to a $212 million in annual revenue in 2003. In "The Seven-Day Weekend", a book by Ricardo Semler, Ricardo explains that the title "The Seven-Day Weekend" as SEMCOs' way of getting out of control business and back to the companies core competencies [8].

SEMCO's policy was to remain a premium player in each of their markets. SEMCO's products were not the lowest priced products or services. Premium products attract intelligent clients who understand risk and understood the price of minimizing risk. SEMCO moved away from clients who did not understand risk, who therefore were low bidding buyers.

SEMCO strove to put employees in a continuous improvement environment. The key concept that each employee was taught first was to understand is to avoid routine. Once they understand this concept, SEMCO then relinquishes control over the employee. In order to move a business or organization ahead, SEMCO directed the minimizing of management and control. SEMCO allowed workers to align their individual goals with the company goals. SEMCO allowed employees to find the optimal job for themselves in the company. They'll let their new employees to wander around the company until they've found out what it is they want to do. Each employee has a special talent. Many companies throughout the world find out who their least productive employees are and immediately give them the boot. SEMCO treats every individual as a unique person who could help the company in a different way. If an employee isn't performing as they should in a particular area of the company, they're not fired. Instead, they're free to discover for themselves where their talents can be used for the company's benefit. Having employees measure, analyze, and control themselves, and dictate how their strengths and talents can assist the company to be successful. By doing this, managers and workers alike respect each other's differences and it helps to create a less stress-free and productive work environment.

Other practices at SEMCO which showed a release of control include:

1. No formal organizational chart.
2. No rules for office organization or dress code.
3. Removed security checks.
4. Delegated to the lowest level.
5. Workers make their own decisions, operational manuals thrown out.
6. Profit sharing across all employees.
7. Employees help managers make decisions.
8. Memos had to have conclusion as the subject and could only be one page long.

SEMCO's practices identify the following concepts:

1. Only stay in business in the best areas.
2. Minimize the management and control functions.
3. Buy and sell based on value.
4. Force everyone to do quality control.
5. Release control to the workers (contractors in the construction industry).
6. Force everyone to measure themselves.
7. Rely on logic instead of bureaucratic systems.
8. Minimize communication.
9. Make people accountable.

This paper proposes that the same concepts used by Ricardo Semler can be used to minimize the problems in construction. Many of the same principles were also used by Jack Welch in the transformation of GE to a highly successful company [9]. Rudy Guiliani used many of these concepts to transform NYC into a safer city. Deming [4], Ohno [6], and Womack [10], proposed the same concepts in continuous improvement, the statistical control process, just in time, quality control, and lean manufacturing. The authors propose using the SEMCO concepts in the following ways:

1. Clients should only hire the best contractors.
2. Management and control of the contractor by the client, and control of the subcontractors by the general contractor should be minimized.
3. Communication between the client and client representative and the contractor should be minimized.
4. Contractors should quality control their own work.

5. Contractors should be at risk and minimize the risk.
6. Contractors to measure their performance.
7. Anything counterproductive should be minimized.
8. The client's representatives should be accountable for their actions as well as the contractor's personnel.
9. Contractor key personnel should be interviewed and rated as well as the general contractor.

4. Movement to Best Value Environment

In order to implement some of these concepts, the construction delivery environment must be changed. The structure of the current low-bid environment has the following practices which immediately run counter to the proposed concepts:

1. The contractor is directed to maximize instead of minimizing risk.
2. The client's representatives minimize risk through management and inspection.
3. There is not trust, no transfer of risk, and management and control.
4. Clients hire the lowest performing contractor instead of the highest performing.
5. Communication between client and contractor is maximized instead of minimized. The specifications have to be more detailed, more complete, and the contractor is also managed.
6. Contractors cannot quality control their own work. If they do, they will not be competitive, and if they disagree with the client's representative, they will be overridden. Minimum standards do not lead to effective quality control.
7. Contractors are not at risk as long as they listen to the client's representative.
8. There is no performance information of contractors or key personnel.
9. Specifications and subjective decision making override logic.
10. Client's representatives are not accountable. There is no performance information on the client's representatives. The only way to get the client's representative to be responsible is to prove negligence.

Figure 1: Construction Industry Structure (CIS)

The major difference between the Price Based environment and the Best Value environment is that the contractor minimizes the risk instead of the client's representative. Accordingly, the following items must occur:

1. The risk is transferred to the contractor.
2. The contractor uses high performance expectations instead of minimum standards to do their work.
3. The contractors will quality control their own work because they now have the responsibility to minimize the risk.
4. Management and inspection by the client's representative is no longer required. Instead, quality assurance must be practiced.
5. Performance information must be used on all critical components allowing price and performance or best value can be used for the selection process.
6. General conditions which are punitive in nature and are designed for contractors, who are not acting in the best interest of the client, can be eliminated.

5. Obstacles in Changing Environments

Obstacles facing clients in implementing a process that releases control include:

1. What to do with the professionals who have made it their livelihood to manage and control and design processes and standards that are required in this controlling environment.
2. Finding a process which minimizes the risk of the client by selecting the best possible contractor option to minimize the construction risk.
3. How to minimize the relationships that spread risk and override performance information.
4. How to educate their personnel who have been taught the concepts of management, control, and inspection.
5. To change the overall concept that management is the solution to problems.

In the latest Construction Owners Association of America (COAA) identified that 58% would hire construction managers from the beginning of design throughout the construction process. Design-build (DB) and construction management at risk (CM@Risk) were created to minimize construction problems. The differential with the design-bid-build process is merely the transfer of risk. However, DB and CM@Risk can still go awry if the client is represented by a professional who wants to manage and control. Clients have to be educated that the construction delivery process is no different than any other delivery process and can be optimized using business best practices of outsourcing, quality control, just-in-time, and the minimization of management and control.

6. Best Value Procurement

The US Federal Government has identified that the method of procurement of services using the price based, specification, and management and inspection is inefficient, keeps the risk with the government, and does not result in a better price or performance [4]. Several federal agencies (Federal Aviation Administration (FAA), US Army Medical Command (Medcom), US Coast Guard (USCG)) have been testing a best value procurement system, the Performance Information Procurement System (PIPS), developed at Arizona State University. The same procurement system has been tested by the states of Utah, Hawaii, Georgia, and Wyoming. Non-government clients who have tested the process include Harvard University, United Airlines, Motorola, Honeywell, Intel, IBM, and Boeing. The process has the following history [4]:

1. Tested over 10 years (1994-2005) on 400 projects ($260M of construction procurement).
2. 98% performance (on-time, no contractor generated change orders, high customer satisfaction)
3. Consistent results over the ten years.
4. Minimizes construction management, control, and inspection by up to 80% of the price based processes.
5. Biggest resistance was from non-value added functions and nonperforming contractors who felt that their livelihood was being threatened.
6. Being introduced for implementation tests in the Netherlands, and introduced into the UK and Finland education/research groups.

The test results are similar to the SEMCO results. The authors propose that construction is similar to other processes and problems of inefficiency and nonperformance should be solved using the same best practices.

7. Performance Information Procurement System (PIPS)

The PIPS best value process differs from other processes in the following ways [4]:

1. The process minimizes technical decision making in the selection of the best value contractor. There is no technical evaluation.
2. The process using past performance information on all critical entities in a contractor's bid.
3. The contractors are forced to identify, prioritize, and how they will minimize the risk on the project in the competitive bid process.
4. The process is "blind." Value of relationships is minimized.
5. The process uses an artificial intelligence system that compares all the alternatives and identifies the best value.
6. The best value is forced to minimize the risk before they are awarded the project.
7. The contractor, who the best value process identifies as the best performer, looks at the intent of the client, and proposes how they will minimize the risk.
8. The contractor does all documentation during the construction.
9. The contractor takes control of the project and makes the client's representatives, users of the future construction, and procurement personnel responsible to cooperate in a timely manner.
10. The performance of the entire group is rated at the end of construction.

PIPS uses the concepts in the SEMCO transformation. The authors propose that the client, contractor, subcontractors, and client's representatives be viewed as a large company. The results of PIPS are as successful as the SEMCO transformation using the same principles.

A recent survey was taken showing that there are no significant differences between the contractor-performed acceptance data and concomitant highway agency-performed verification data [5]. A consensus of random states took part in the survey. The study proved to show that the performing contractors testing seemed to be more accurate than that of DOT officials. Not only that, but both the DOT and hired contractors felt that the overall construction quality and meeting the schedule was evident by having contractor performed quality control. The only concern, stressed by the DOT, was that the DOT felt they had to have trust in the contractor [5]. The authors propose holding the contractors responsible for the construction, very similar to bonded warranties.

The prevailing practice in construction is still to manage and control the contractors. Of the over 200 construction management education/research programs in the United States, only one unit has an education/research program that assists clients to maximize construction performance by minimizing construction management/inspection.

A concentrated effort is being made to take the education/research to the largest construction programs in each sector of the country. The first prototype was at Central Connecticut State University. The second university will be Colorado State University, and the third will be Florida International University.

8. Conclusion

Ricardo Semler and SEMCO used concepts which minimized management and control to increase their business tenfold. SEMCO had many of the same traditional control mechanisms that are found in today's construction industry. The authors identified the concepts and discovered that the same concepts were already being tested in the construction industry. The same concepts have been proposed by Deming, Taiichi Ohno and James Womack, and Jack Welch in the manufacturing industry. If these concepts are correct, it identifies the major sources of construction nonperformance being the client's inability to identify performing contractors, inability to release control to the contractors, and the inefficiency and nonvalue added functions of construction management. The authors are proposing that the construction industry must move from the price based to the best value environment. Efforts to maximize the performance of construction in the price based environment have been unsuccessful and inefficient. The authors recommend that construction research groups consider changing their focus from optimizing contractor operations in the price based environment to turning the control of construction to contractors, minimizing the use of construction management, and educating construction clients on the potential of the changing from a price based to a best value environment. The authors propose that construction education consider teaching that construction management belongs with the contractor who is awarded a construction project, and should not be a third party or representing the client.

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Appraisal of Subcontractor Performance – Criteria and their Importance

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Abstract

Several influential industry reports have pointed out that a decline in construction quality and productivity could be attributed to the performance of subcontractors who are entrusted to complete majority of the actual works, yet subcontractor performance appraisal is a much neglected subject in construction. A review of the current practice reveals that only some public clients have been keeping track on subcontractor performance based on certain vague criteria. To facilitate subcontractor registration, management and/or selection, an equitable and reliable framework for appraising subcontractor performance would be indispensable. This paper reports the findings of an empirical study conducted in Hong Kong focusing on the criteria for used in subcontractor performance appraisal and their importance. The paper begins by identifying a list of criteria relevant to and suitable for appraising subcontractor performance. Criteria having a high significance to subcontractor performance appraisal are highlighted. Finally, a strategy for scrutinizing the information is proposed to minimize the potential bias induced by the use of qualitative information.

Keywords: Construction subcontractors, performance appraisal, evaluation criteria

1. Introduction

Subcontractors play a significant role in ensuring the success of construction projects, as up to 90% of the total project value are entrusted to various subcontracting firms [1]. Despite that, to survive in a highly competitive market, many lower tier contractors are tempted to recover their desired profit by cutting corners. This could result is a decline in productivity and quality [2]. A general dissatisfaction with the current practices of subcontracting [3] has prompted the introduction of various measures that aim at enhancing the performance of subcontracted works. Examples of these include subcontractor registration schemes [4,5,6] and mandatory disclosure of subcontracting firms at the time of bidding.

Other initiatives include restricting the percentage of work to be subcontracted especially for works of significant importance or where testing, supervisory or performance control is difficult. To promote a non-confrontational relationship, researchers [7] proposed extending the partnering arrangements to cover main contractor and subcontractors so as to help improve the co-ordination and management of subcontracted works effectively. Certain clients now insist on partnering as one of the requirements for contractor selection in their projects [8,9].

While those initiatives may reduce the possibility of recruiting incapable subcontractors, the main contractor and project team seldom measure the performance of subcontractors appointed in a systematic manner [10]. In view of the growth in the size and complexity of subcontracts, there is a need to monitor subcontractor performance more closely [11]. The development of a practical and objective framework for subcontractor appraisal is, therefore, relevant to the current trend and needs of the industry.

The desire to improve the practice of subcontractor performance appraisal has aroused a series of research in Hong Kong. Amongst that, an empirical survey was conducted to examine the importance of criteria for subcontractor appraisal. In this paper, the criteria used by various organizations in appraising subcontractors are first outlined. It is then followed by a brief introduction to the research method. The importance of decision criteria is presented, and the most important subcontractor appraisal criteria are discussed. Finally, a method for evaluating the decision criteria is proposed.

2. Existing Subcontractor Appraisal Models

An extensive literature review and web search unveils the existence of a several established subcontractor performance appraisal models around the globe. These include the models developed by the State of Wisconsin, South Carolina State Government, Los Alamos National Laboratory (LANL), and Fermi National Accelerator Laboratory (FNAL). As the emphases of these models are not the same, there are slight variations in the criteria employed.

2.1 State of Wisconsin's Model

The Wisconsin model [12] is used for appraising the performance of contractors and subcontractors involved in projects commissioned by the State of Wisconsin, USA. The appraisal mainly focuses on (i) schedule; (ii) quality; (iii) cost; (iv) safety; (v) relationship; (vi) communication; and (vii) documentation. These criteria are generic to all contractors and subcontractors, and all criteria carry equal weighting. Compared with other available models, guidelines and procedures provided in this model are by far the most comprehensive. Detailed definitions on the ratings and performance indicators are available, while the guidelines are designed in question form in order to stimulate the thinking of assessors when reviewing the performance of subcontractors.

2.2 South Carolina State Government's Model

The key criteria adopted by the South Carolina State Government for appraising their contractors and subcontractors [13] are very similar to the Wisconsin model. Despite that, this model is rather primitive when compared with that of the State of Wisconsin, as the definitions of the criteria and factors to be considered when completing the report are not clearly specified in the model. Different assessors may, hence, have different interpretations on the criteria and this could affect the objectiveness of the model. A major feature of the South Carolina model is that assessors are required to enter not only the rating but also the weighting for each indicator to reflect its importance. However, weightings are assigned by assessors after discussing with subcontractors, and this could give rise to controversial and biased decisions. The difference in yardsticks renders the comparison among subcontractors difficult if not impossible.

2.3 Los Alamos National Laboratory's Model

The LANL model [14] is designed for measuring the performance of subcontractors who are engaged in the environmental restoration projects of the Laboratory. The criteria adopted in the LANL model include: (i) compliance with planned schedule; (ii) submittal of administrative procedures; (iii) deliverables; (iv) notification of anticipated delays of regulatory deliverables; (v) thoroughness and accuracy of work; (vi) quality program implementation; (vii) compliance with environmental/waste management regulations; (viii) effectiveness/communication; (ix) teamwork; (x) adherence to cost estimate; (xi) adherence to site-specific health and safety plan/health & safety plan/regulations; (xii) occurrence of imminent safety or health incidents or serious safety or health incidents; and (xiii) lower-tier subcontractor safety performance. Comprehensive guidelines and procedures are provided in LANL model. For instance, detailed definition for each criterion and rating is stipulated to avoid possible misinterpretation. While weighting is not considered in this model, assessors have to enter the rating for each criterion to obtain the total score relative to the norm. To increase the transparency of the appraisal process, subcontractors can review and comment on the relevancy and accuracy of the performance report.

2.4 Fermi National Accelerator Laboratory's Model

FNAL is a laboratory specializing in high-energy physics research, and the FNAL model [15] is therefore designed for evaluating the performance of this type of subcontractor. However, the criteria *viz.* (i) business relations; (ii) management of key personnel; (iii) schedule; (iv) cost control; (v) health and safety; and (vi) performance/quality of works, are equally applicable to construction subcontractors. The criteria carry equal weight in the FNAL model. Furthermore, brief definitions on the criteria and ratings are given despite more details on the procedures and definitions of criteria could have been provided to improve the fairness of appraisal.

2.5 Environment, Transport and Works Bureau's Model

Although there is yet to be a subcontractor appraisal model in Hong Kong, a framework for monitoring the performance of main contractors [16] has been developed by the Environment, Transport and Works Bureau (ETWB). The ETWB model examines the: (i) progress; (ii) site safety; (iii) resources; (iv) design; (v) attendance to emergency; (vi) organization; (vii) general obligations; (viii) industry awareness; (ix) workmanship; and (x) environmental pollution control. While these criteria are used for assessing the performance of main contractors, it is worth examining whether they can be applied to subcontractor appraisal.

3. Subcontractor Appraisal Criteria

In order to formulate a common set of performance appraisal criteria for the subsequent study, criteria used in the models described above are summarized in Table 1. Based upon the criteria of the ETWB model, other criteria appeared in the established subcontractor appraisal models including "adherence to cost estimate", "relationship" and "communication" are added.

Table 1: Criteria used in various subcontractor appraisal models

Indicator	*State of Wisconsin*	*South Carolina State Government*	*Los Alamos National Laboratory*	*Fermi National Accelerator Laboratory*	*Environment, Transport and Works Bureau*
Workmanship	✓	✓	✓	✓	✓
Progress	✓	✓	✓	✓	✓
Site safety	✓	✓	✓	✓	✓
Environmental pollution control	✗	✗	✓	✗	✓
Organization	✓	✓	✓	✓	✓
General obligations	✗	✗	✗	✗	✓
Industry awareness	✗	✗	✗	✗	✓
Resources	✗	✗	✗	✗	✓
Design	✗	✗	✗	✓	✓
Attendance to emergency	✗	✗	✗	✗	✓
Attitude to claims	✗	✗	✗	✗	✓
Adherence to cost estimate	✓	✓	✓	✓	✗
Relationship	✓	✓	✓	✓	✗
Communication	✓	✓	✓	✗	✗

Legend: ✓ *= Same or similar indicator is adopted in the assessment model concerned*
✗ *= Same or similar indicator is not adopted in the assessment model concerned*

As shown in Table 1, "workmanship", "progress", "safety" and "organization" are adopted by all models for assessing subcontractor performance. The Wisconsin, South Carolina, LANL and FNAL models, however, do not put particular emphasis on "general obligations", "industry awareness", "resources", "design", "attendance to emergency", and "attitude to claims". Having considered the peculiar situation of Hong Kong, virtually all identified key criteria were considered to have a high potential for use in appraising subcontractors except for "design" and "adherence to cost estimate" (Table 2).

Table 2: Suitability of subcontractor appraisal criteria

Indicator	*Suitability for further study*	*Reason*
Workmanship	✓	This is the common criteria appeared in all reference model.
Progress	✓	This is the common criteria appeared in all reference model.
Site safety	✓	This is the common criteria appeared in all reference model.
Environmental pollution control	✓	As subcontractors are the parties that actually carry out the works, their strict compliance of the relevant contractual requirements or regulations is critical in protecting the environment.
Organisation	✓	This is the common performance indicator appeared in all reference model and hence should be adopted in the questionnaire survey
General obligations	✓	This criteria does not appear in the subcontractor assessment models of the US. The reason behind may be that subcontractors normally concentrate their effort on the works only while compliance of general obligations rests with main contractors. However, this is not the case in Hong Kong situation. The subcontractor has to comply with the general obligations such as the cleanliness of site, care of utilities, etc. in executing the sub-contracted works.
Industry awareness	✓	This criteria does not appear in the subcontractor assessment model of the US. However, in order to encourage the subcontractor in providing more training opportunity for the trainee craftman as well as the care and welfare of workers, this criteria should be included.
Resources	✓	The resources of the subcontractor directly affect the progress of the works and hence should be equally important as or even more important than the resources of the main contractor. If resources are considered as an indictor for the performance of a main contractor, there is no reason why it should not be considered alike in assessing the performance of a subcontractor.
Design	×	The client normally does not require subcontractor to design permanent works in Hong Kong.
Attendance to emergency	✓	This critieria is critical as subcontractors are required to respond to emergency works as needed to avoid possible delays and disruptions.
Attitude to claims	✓	This criteria is important when partnering approach is not adopted. The attitude of the subcontractor in claiming additional cost could affect the final contract sum as well as the administration cost borne by the client.
Adherence to cost estimate	×	In Hong Kong, as the clients normally rely on consultants to prepare the cost estimation, this indicator is less important to subcontractors.
Relationship	✓	It appears that partnering will become a trend for construction projects in Hong Kong, it is worthwhile including this criteria for further consideration.
Communication	✓	Good communication is essential to the success of construction projects.

Legends: ✓ *= The indicator is recommended for further study in the sub-contractor assessment model*
× *= The indicator is not recommended for further study in the sub-contractor assessment model*

4. Research Methodology

A questionnaire survey was conducted to establish which criteria are more important to subcontractor performance appraisal in Hong Kong. Based upon the 12 key criteria as shown in Table 2, a total of 29 sub-criteria were identified for the questionnaire survey. Respondents were requested to express their perception on the importance of the 29 detailed criteria through a 5-level Likert scale, with 1 representing "very low" importance and 5 indicating "very high" importance.

4.1 Sample Frame

Since the criteria are used for appraising subcontractors, it is unrealistic to assume the views of the main contractors would adequately reflect the concerns of subcontractors. On the other hand, as the clients and consultants may play a less predominant role in subcontractor appraisal (as domestic and specialist subcontractors are employed by main contractors instead), the collective views of the clients and consultants should reflect their position as a policy enforcer.

Random samples were drawn from the three stratified sample groups of client/consultant, contractor and subcontractor. In this study, a sample size of 100 was set for each of the three stratified sample groups. A total of 35, 33 and 24 valid replies were received from the client/consultant, contractor and subcontractor groups respectively, representing an overall response rate of 30.7%.

4.2 Method of Analysis

The 'mean score' method [17] was adopted for analysing the collected data. The mean score (MS) for each indicator was computed by the following formula:

$$MS = \frac{\sum(f \times s)}{N} \qquad (1 \le MS \le 5)$$

where s = score given to each criterion by the respondents and ranges from 1 to 5
f = frequency of responses to each rating (1-5) for each criterion
N = total number of responses concerning that criterion

The rank order, in descending order of importance, of the 29 subcontractor performance appraisal criteria was determined by comparing the individual mean score.

5. Results and Discussions

Table 3 summarizes the mean score and ranking of each subcontractor performance appraisal criterion. It is apparent that the most important criteria include: “standard of workmanship”, “action taken to mitigate delay”, “communication”, “identification of and responsiveness to problems”, and “provision and maintenance of work environment”.

Table 3: Importance of subcontractor performance appraisal criteria

Performance Criteria	*Level of Importance*					*Average Score*	*Rank*
	Very low (1)	*Low (2)*	*Moderate (3)*	*High (4)*	*Very high (5)*		
Standard of workmanship	3	0	17	42	30	4.04	1
Action taken to mitigate delay/catch up with programme	2	3	17	45	25	3.96	2
Communication	0	5	21	39	27	3.96	3
Identification of and responsiveness to problems	0	4	24	41	23	3.90	4
Provision and maintenance of work environment	3	3	28	24	34	3.90	5
Coordination of contractors	1	2	24	48	17	3.85	6
Suitability of method and sequence of work	3	1	22	47	19	3.85	7
Standard of materials or equipment supplied	3	3	22	44	20	3.82	8
Adequacy of site supervisory staff	1	5	25	42	19	3.79	9
Compliance with statutory requirements	2	3	26	42	19	3.79	10
Adequacy of labour resources	2	2	24	50	14	3.78	11
Achievement in progress	2	4	25	46	15	3.74	12
Care to general public	2	4	27	42	17	3.74	13
Care of works	1	3	31	42	15	3.73	14
Provision and maintenance of plant	3	4	29	35	21	3.73	15
Coordination with subcontractors	1	5	29	41	16	3.72	16
Adequacy of material resources	2	2	31	43	14	3.71	17
Reasonableness of monetary claims	3	5	32	30	22	3.68	18
Adequacy of planning	0	8	25	47	12	3.68	19
Adequacy of plant resources	0	7	31	39	15	3.67	20
Action taken to remedy non-compliance	1	6	30	40	15	3.67	21
Adequacy of programme	4	1	28	48	11	3.66	22
Reasonableness of extension of time claims	3	6	33	30	20	3.62	23
Compliance with non-environmental enactments	2	4	35	38	13	3.61	24
Standard of temporary works	3	7	28	40	14	3.60	25
Compliance with environmental enactments	1	8	35	34	13	3.55	26
Adequacy of notice for inspection of works	1	4	38	42	7	3.54	27
Adequacy of pollution avoidance measures	1	7	40	28	15	3.51	28
Care and welfare of workers	4	6	46	27	9	3.34	29
Cleanliness of site	2	13	38	32	7	3.32	30
Training of apprentices, graduates and craftsmen	9	7	34	31	11	3.30	31

Standard of workmanship: From the client's perspective, good standard of workmanship can ensure the designed life of the services; minimize the costs on maintenance; and reduce future disruption to the services caused by the repairs. In the ETWB model, poor workmanship results in a "poor" overall performance automatically and the performance report will be rated as "adverse". As subcontractors are the party who perform the construction works, their standard of workmanship is of paramount importance. The contractors and subcontractors consider good standard of workmanship can enhance their goodwill and hence result in greater opportunities to new jobs.

Action taken to mitigate delay/catch up with programme: For public schemes, delay in project completion would inevitably cause social disruption. However, any delay in private developments would mean postponement in sale and hence a financial loss due to extra interest on loan capital. The contractors and subcontractors also see this as an important criterion as liquidated damage and poor performance report will be resulted from any delay project completion.

Communication: Good communication can minimize misunderstanding, develop good relationship and improve productivity of works. While contractors may be in a more suitable position to determine whether subcontractors have any "communication" problem which could affect the project outcomes, communication with the client and the project team is also needed in a multidisciplinary environment. Therefore, it may be a good practice for both the contractor as well as the client/project team to assess this important criterion.

Identification of and responsiveness to problems: Problems may grow if they are not identified and addressed promptly. Being the one who is responsible for the actual work, subcontractor are expected to keep the project participants informed of the potential problems and propose solutions to prevent any possible delays and reworks. The ability of subcontractors in resolving problems is the most obvious means to determine the effectiveness and efficiency of their organization. Obviously, problems cannot be identified early and solved promptly without good communication, supervision and executive authority of the subcontractors.

Provision and maintenance of working environment: In recent years, continuous and considerable effort has been made by the government and the industry to promote site safety via legislation, education and upgrading safety requirements. It appears that all parties including subcontractors acknowledge the importance of site safety now. All construction stakeholders understand that site safety brings about indirect benefits which will eventually contribute to the direct ones by creating a better working environment and reduced risks.

6. Conclusions

In this paper, a list of criteria pertinent to subcontractor performance appraisal has been established. The results of a survey conducted in Hong Kong indicate that "standard of workmanship", "action taken to mitigate delay", "communication", "identification of and responsiveness to problems", and "provision and maintenance of work environment" are the most important criteria for appraising subcontractors. It is necessary to ensure that these criteria are carefully incorporated in the subcontractor performance appraisal model.

Despite that, the most important criteria like the "standard of workmanship" may not be very easy to measure even when guidelines or procedures exist. As a result, expert judgment is inevitable in establishing the benchmark. To improve the fairness and transparency of subcontractor performance appraisal, the evaluation must be founded on unequivocal yardsticks instigated by the objectives and expectations of the client.

In recent years, certain organizations, such as the US Department of Commerce, Canadian Government, etc., has begun to realize the benefits of the Balanced Scorecard and Gap Analysis techniques and apply these methods to various kinds of performance-based appraisal schemes including business, environment, quality, etc. The research team is exploring the full potential of these techniques in promoting the objectiveness and transparency of subcontractor performance appraisal, and the results of analyses will be reported in due course.

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Delivery Systems as Service Processes in Building Projects

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Abstract

This paper discusses the challenges in examining project delivery systems as service processes. Delivery systems are categorised in four different ways according to the requirements of clients. Certain clients prefer conventional delivery systems and enter into the main construction contract with or without nominated sub-contractors. Project management and design-build systems have gained a significant market-share, too. This paper focuses on project development systems as there is a demand for developing after-sales services which guarantee a long-term profit for investors. The issues for clients in choosing as well as the issues for service providers in offering total service packages, are briefly described. A case study of a market-financed rental housing project is presented as an example of how after-sales services can be included in the service process of a building project.

Keywords: Project delivery system, building procurement system, service process, client, project development, design-build, construction management, building construction, Finland

1. Introduction

In Finland a great deal of effort has been made to develop the building process [1]. The objective has been to promote the internal effectiveness and international competitiveness of Finnish construction industry. In particular, the employment of a design–build approach has been promoted as a means of encouraging innovations by combining the design and production planning sides [2]. At the same time, the use of construction management approaches has increased. Nevertheless, the traditional systems i.e. the main contracting with nominated sub-contractors, have continued to dominate the market because clients want the ability to influence the design [3].

On the other hand, there are clients who are not interested in how the building project is organised. The trend in the real estate market, now that foreign investors are also entering Finland, is that clients consider a built project as one alternative way of investing among existing real estate or other alternative investment options. The major players are forced to enlarge their service supply both to make sure that users' demands are met and to help investors achieve the expected profits.

Major Finnish construction companies like YIT Rakennus Oy, NCC Finland Oy, Skanska Oy and SRV Viitoset Oy have created their own business park concepts to satisfy the demand of those investors interested in commercial properties. A necessary service element has been to commit at least the main user to the planned working environment. Some insurance companies have also utilised project development systems in rental housing production to spread and lower the investment risk.

New services included in built projects are constantly being explored, for example, to guarantee the rest value of the premises as well as guaranteeing the premises are kept attractive for users. However, the problem seems to be that clients are not convinced that the increased added value is worth paying for. The delivery systems are commonly difficult to demonstrate as clear service processes because the terms used in the field are vague. For example, the largest office building project in Helsinki Kamppi is organised and presented with a construction management approach, but the contractual relationship with the city of Helsinki is based on design-build responsibility.

It is hoped this paper will help to analyse different delivery systems from the service process perspective. The aim is to achieve a holistic view of the services included in building projects and thus to give ideas to develop service management. The objective is to promote the understanding of the overall service business in building projects.

2. Traditional Analysis Methods for Delivery Systems

Project delivery system is defined as a comprehensive process to deliver a built project to the owner [4]. However, the procurement system could be defined as the most appropriate method of procuring according to client choice after the decision to build [5]. The choices to form a building procurement or delivery system is varied and categorising them difficult [5].

Traditionally, procurement methods have been analysed according to the responsibilities, the contractual relationships and, less frequently, the ways of inviting tenders. Besides the design and supply, the responsibilities concern the pricing methods, as well as the preparedness of design documents. The vast variation of alternative options stems from the great number of client decisions.

Together with the task allocation, procurement systems can be described through customer-orientation with the help of information transfer and co-operation [6]. The ability to respond to risks and to reach the set project aims can provide selection criteria for procurement options to promote positive and hinder negative project outcomes [6].

When the service providers offer their own concepts, analysis of differences between the delivery systems play a key role. In the international market the one-point-responsibility seems to be significant for design-builders [7]. In project management methods the co-operation with the client both in design and in procurement stage is emphasized [8]. This form of categorising is flexible as all kinds of demanded services are included in existing delivery systems and new service packages have been created from the basis of old ones.

3. Clients in Building Project Business

3.1 Definition

"Client" in this paper is considered to be an organisation that hires professional services from the Finnish building market such as investors as well as public and private owners, who decide how to procure a building project. "Service" is a tailored solution for the client who participates in the service production process [9]. So it is essential to enter into the client's decision-making and, preferably, before the decision to build new facilities is made. Certain services are assumed to be included in defined delivery systems and certain services are self-evident in all of them.

3.2 Operating Environment

The Finnish construction market is characterised by its small size. There are fewer than ten large construction companies with the ability to take on the economic risk of larger building projects. The other companies are small and medium size firms. Architectural and engineering companies are small firms without the resources to take on at-risk responsibility for project management. Few differently oriented project management consultants are available.

In principal, it has been impossible for the firms to build a competitive advantage based on technological benefit or lower cost in built projects [10]. In other words, it has not been possible to differentiate the core product. Individual successes have been based on convenient site location or personal relations. It seems that functioning core products are available in the field, but because long-term relationships have not become common, there are currently no fully functioning total service offerings.

Issues in the operating environment in the building project market are the following:

- The whole building sector is fragmented and the heterogeneity is challenging to manage.
- The core product is less often the reason for dissatisfaction than the surrounding services. Investing in services has not paid off.
- The running costs of working environments are not reasonable and they are not easily calculable apart from in apartment buildings.
- Premises should be suitable for changing purposes.

- The difficulty is to influence the client's decisions-making by offering attractive ways to organise the projects. Traditionally, what is offered is what is demanded, but in more hi-tech industries the firms have been more innovative and forward-looking.

3.3 Triangle of Investor, User and Service Provider

It is obvious that the competitive edge in offering building project lies in the services. In most cases, the service provider is required to manage the expectations of the owner as well as the users and integrate them (Figure 1). The triangle has to be taken into account when developing the service management strategy for project development.

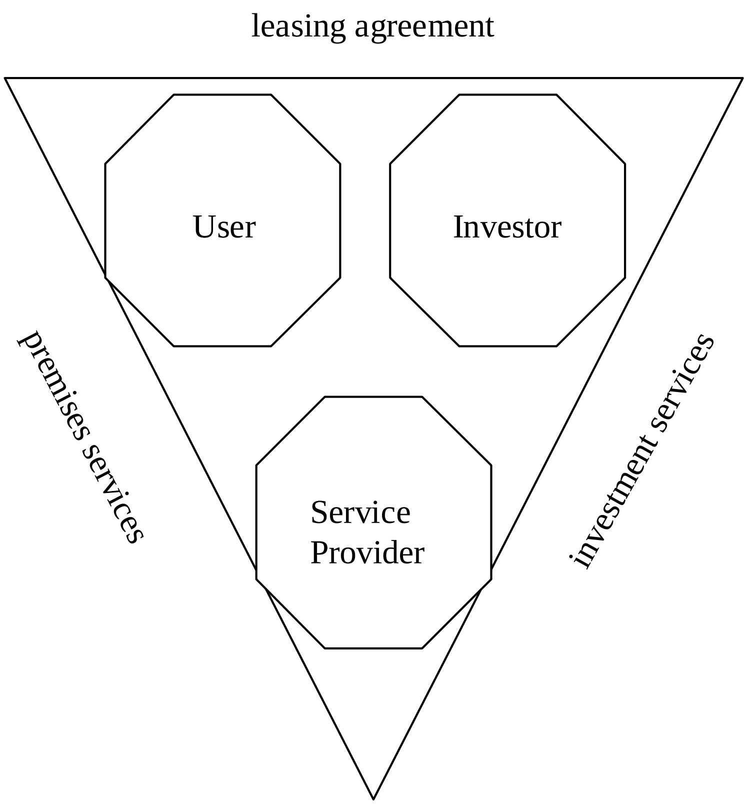

Figure 1: The customerships in project development from the clients' point of view.

3.4 Service Competition

The delivery systems have been categorised in four groups according to the services most of the clients demand from the project implementer. Traditional contracting is for the owners that use separated procurement systems and want to deal with all the organisations involved in the project. Design-build is a system where clients appreciate the one-point-responsibility. In construction management systems clients want to have a greater involvement in the project and the physical construction is carried out by means of packages. Development projects are available for investors to whom building project is just an alternative to invest in. The user is the owner's client and definitely the most important partner for the service provider.

Any quality problems stem from functional quality because all the firms can produce approximately the same technical quality. The trend in the business operations is to include more and more added value to the delivery systems. Formerly the competition concerned the price of materials and labour, but nowadays the operators are in the middle of service competition. In any case, customer satisfaction is hard to achieve and the reason could be that too little attention is paid to the recovery services.

3.5 Service Encounters in Different Delivery Systems

On the following tables, services which clients typically expect with different procurement approaches are listed. The service encounters, that are relevant when evaluating a suitable delivery system, are different on separate organisational levels. On the strategic level the investor decides in which manner the money is invested (Table 1). On the project management level (Table 2) service encounters that help to reach the set project aims are of importance. The key level is the operational one (Table 3) as the user of the premises will pay for the whole process.

Table 1: Service encounters in different delivery systems in strategic level where the demand is for a sound investment. The emphasis is in the after-sales services offered before the project is commenced.

STRATEGIC LEVEL	**Development projects**	**Construction Management**	**Design-Build**	**Traditional Contracting**
Cash flow promises	X			
Leasing responsibility	X			
Financing	X			
Site selection	X			
Life-cycle guarantee	X			
Maintenance	X			
Repairs and replacements	X			
Rebuilding	X			

Table 2: The service encounters offered typically for the managerial level where the demand is for a successful project during design and construction period. The emphasis is on the accomplishment of the contract.

MANAGERIAL LEVEL	**Development projects**	**Construction Management**	**Design-build**	**Traditional Contracting**
Programming	X			
Consultant selection	X	X	X	
Feasibility studies	X	X	X	
Comprehensive responsibility	X		X	
Product modelling	X	X	X	
Power to control design	X	X		
Power to control procurement	X	X		
Cost and value engineering	X	X	X	
Examining alternative design solutions	X	X	X	
Design development and coordination	X	X	X	
Cost control	X	X	X	
Constructability view	X	X	X	
Cooperation with Authorities	X	X	X	
Change order management	X	X	X	X
Construction supervisor	X	X		
Project portal	X	X	X	
Insurances	X	X	X	X
Guarantees	X	X	X	X
Liabilities	X	X	X	X

Table 3: The service encounters offered typically for the operational level where the demand is for working premises when the user operates the building. The emphasis is on maintenance and performance.

OPERATIONAL LEVEL	**Development projects**	**Construction Management**	**Design-build**	**Traditional Contracting**
User Services	X			
Maintenance	X			
Service recovery	X	X	X	X
Project Portal	X	X	X	

Most services are for the management level to achieve and to accomplish the contract. Few services are offered to the users. User services are based on partnering such as occupational health care, catering, telecommunication, fitness services and secretarial services.

3.6 Service Profiles of Delivery Systems

Analyzing the service-orientation of different delivery systems will be useful in describing the roles of the participants in the service process. In figure 2 the service profiles illustrate implementor's service process as well as the clients' participation in the building process. Service profiles can also be one way to roughly compare the delivery systems to each other. The profiles give an image of the significance of the users' participation, too.

Traditional procurement is suitable for clients that are interested merely in the core product i.e. the price of construction. The widest service package is included in project development systems and at the same time the construction stage itself seems to be less important. The one-point responsibility can be an obstacle to clients participation in the design-build service process but at the same time it can save the owner's resources. The project management systems are appropriate for clients who want the power to control the process during the design and construction stages.

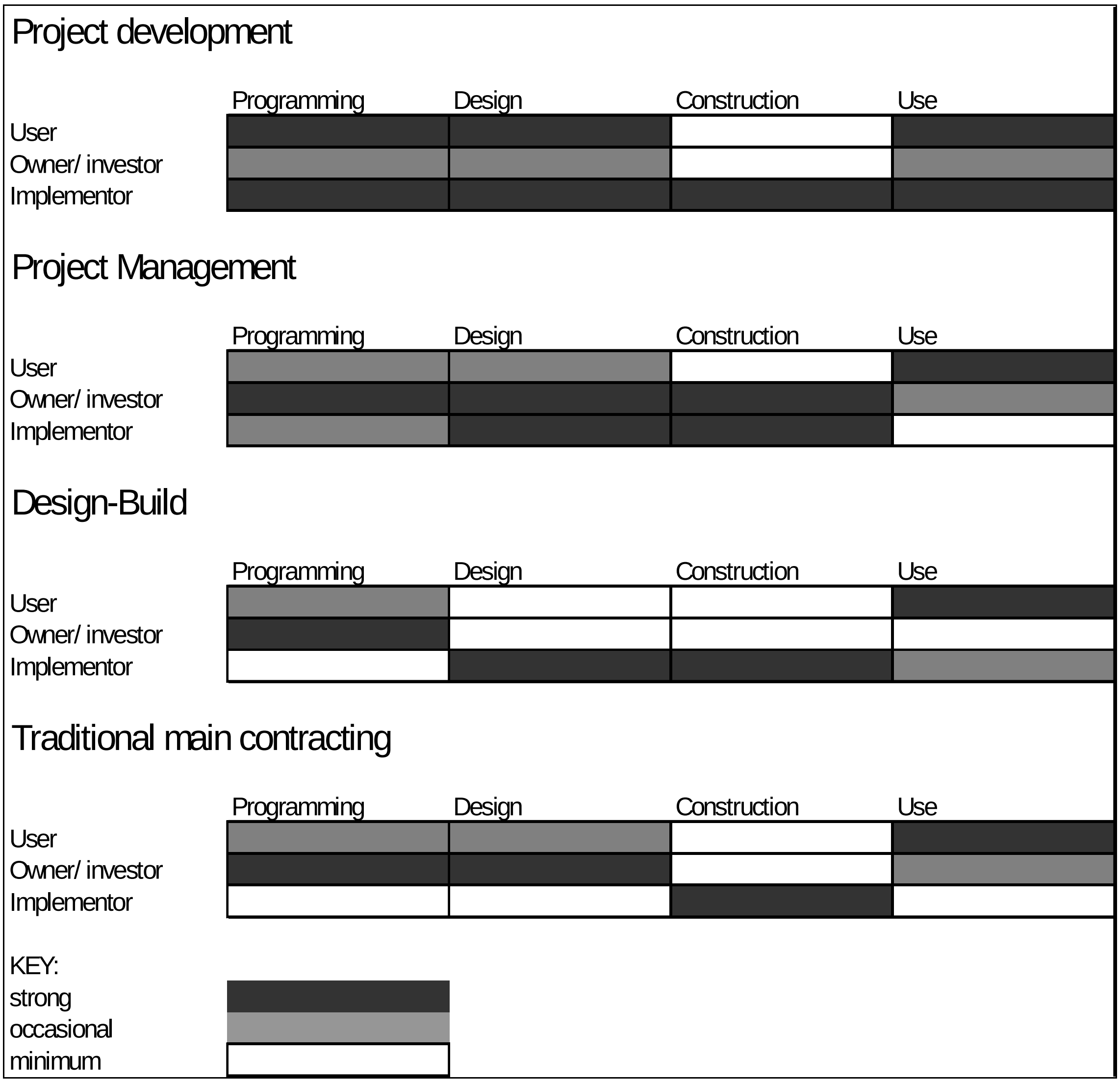

Figure 2: The service profiles of different delivery systems.

4. Guarantee in Rental Housing Projects

4.1 Residential Building Projects

There will be a continuous need for new apartments in the next decade because people are moving from the northern parts of Finland to the greater Helsinki area. The main new housing production is market-financed characterised by the fact that the founding shareholder of a housing company sells the housing shares at the construction stage. Most often the major construction companies are the founding shareholders. Customers as shareholders will form the new board of the housing company after buildings are approved for use.

4.2 Service Package for Residential Real Estate Investors

Market financed housing production is very sensitive to any negative fluctuations in the economic situation especially to changes in interest rates. To prepare for the future risks YIT Rakennus Oy started a product development project to build up a service package for private housing investors. The aim was to offer an agreed profit level by guaranteeing a balance between expenditure and long-term ownership.

According to figure 3, the focus is on the after-sale services instead of site selection, design and construction. To guarantee the agreed profit level, services are provided to take account of both incomes and expenditure. Besides, clients can benefit from the increase in value of the residential property. The idea was to emphasize customer-orientation by keeping the decision-making close to the clients. This means that all the services are options and they can be tailored for each client differently.

The location of the project and the apartment program is the basis for the service provider to commit to the rental revenue and to take responsibility of the renting. Maintenance costs in blocks of flats can be quite accurately estimated and thus the risk of overruns is managed. Certainly, the maintenance serves to keep the property attractive for the tenants.

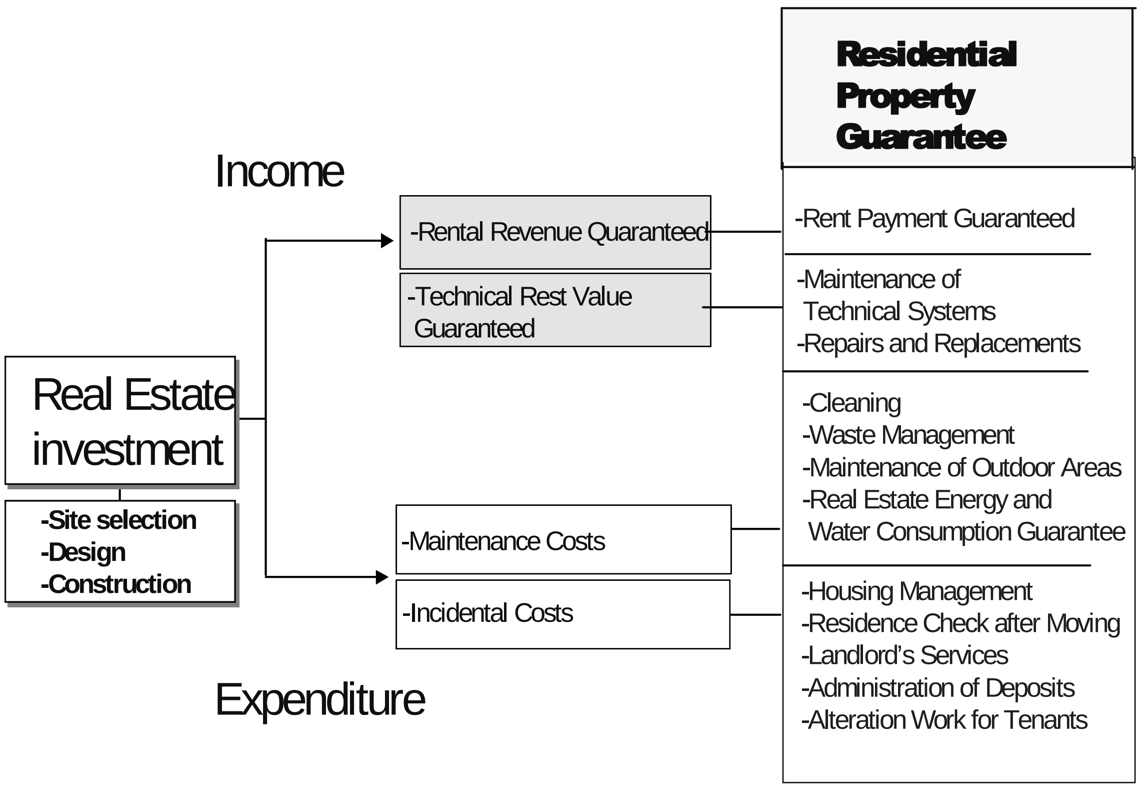

Figure 3: Guaranteed investment in market financed rental housing.

This development work continues. Firstly it has not yet been tested whether the clients appreciate the value of these services and are willing to pay for them. Secondly we must learn how the long-term cost affects our clients. Finally, clients will always remain who are only looking for a core solution and they are not interested in value-adding additional services.

5. Future Service Processes

To develop the future building project delivery systems there is a need for analyzing and comparing the existing, both domestic and international, systems from the service perspective. This kind of study will help clients in decision-making from the earliest stage of a building project. For the operators, perhaps, the results would be of help in service management when the knowledge as well as the weaknesses, the firm has, can be identified. The following benefits may also accrue.

- The ability to describe the service totality to clients will be improved.
- Low price will not be the only decision criterion and clients are willing to pay for the new services.
- It will be easier to market new building projects from the service point of view.
- A core product or the quality of the new facilities is self-evident, but the service quality can vary easily. Quality gaps can be minimised as promises and expectations are more likely to be met.
- There will be expertise to offer all the procurement methods available and to add new options to meet clients' objectives.
- The services as a means of differentiating from the competitors will be encouraged.

6. Conclusions

Service components have become more essential parts of the building procurement than the core product itself. To keep their competitive edge large construction companies will not only offer the facilities, but their complete maintenance, servicing and repairs. Guaranteeing incomes for the future real estate owners will also be necessary.

There will always be a demand for all types of delivery routes. The trend is towards more added value and more sophisticated services. The firms in the field will put effort into differentiating readymade after-sales services that are new to the branch. However, all delivery systems will remain in use because clients' needs, project characteristics and the market situation will vary significantly.

Service concepts will surely become more common in the housing sector, too. Guaranteeing both incomes and expenditures are obligatory services to make the institutional investors invest in residential real estate. In addition to products for investors, purely demand-oriented service encounters, like housing companies for senior citizens including nursing services with reliable partners, will emerge.

To adopt more responsive responsibility for the clients' business, necessitates a vast number of services offered within the delivery systems. Through effective management of these services, success in the market can be achieved.

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Developing the Decision-making of Step-in Rights for BOT Projects

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Abstract

As economy slows down, the BOT/PFI projects become popular in many countries. BOT procurement is undertaken on a service-based output basis rather than an asset delivery basis. Major studies and efforts focused on financial arrangements or project construction management. No serious research on the public sector's step-in rights related issues nor were relevant significant cases been analyzed. To address the uncertainty nature of BOT projects within operation period, the public sector's action should follow Pareto rule, namely to develop a decision–making process which (1) maximize the efficiency of resource allocation and income distribution as well as (2) minimize the transaction cost. Satisfying these objectives is a challenging task that requires identifying tradeoffs among themselves. This paper presents a case study for examining one of the very first PFI agreements in 1993 and the renegotiation of the deal in 1999.The analysis provides some valuable lessons which could be learned from this particular deal for future BOT/PFI contracts design. Furthermore, the outcome of the study will be interdisciplinary works which provide a new approach to BOT/PFI regulators and contracting parties without discrimination.

Keywords: BOT, decision-making, benchmark approach, contract-designing, option theory

1. Introduction

The outset of the Private Finance Initiative (PFI) in 1992 provided concession-based deals which were generally produced on a limited recourse or project financial basis. For the private sector entity to undertake such a long term commitment, it must have sufficient funding to deliver the contracted-for service as well as to ensure that project may be build and then operated and maintained.

Inevitably, BOT/PFI procurements are for the delivery of what amount to indispensable service to the public. The absolute necessity to deliver these services has led to unusual contractual requirements within public-private concession contracts. Legal issues arise across a very broad area and need to be identified carefully. Early studies indicate that governments will seek step-in rights in a board range of circumstances, such provisions are not only made for the public sector to be able to intervene earlier in the event that the private sector is not delivering service to the performance standard but also alarm lenders and other investors - they will not recover the investment they have made in the project unless the private sector borrowers is delivering services and being paid for such services.

1.1 Scope of This Study

We shall introduce the study conducted by researchers on financial and economic law analysis first, and then we shall adopt modern research on real option models and benchmark approaches, to discuss how they can be related with our research objectives. As to contract design related monitor issues arise within the operation period for example, are whether the establishment of the project was consistent with the public sector's long-term business strategy; how the private sector's problems arose; whether the terms of the original contract aided the resolution of crisis; what options considered to tackle the crisis; what the terms were of the revised agreement made to save the project. We tried to collect the evidence in support of our opinions under each of these issues from examination of the Royal Armouries case. According to the scenario case study, this article shows some strategies for improvement of the decision-making system in order to reduce the risk of BOT/PFI projects within operation period...

The paper is structured as follows:

- part 1 contains overview of BOT/PFI and identifies performance risk within operation period;
- part 2 considers step-in rights and provides methods to formulate the critical time issue;
- part 3 reviews an empirical case and examines decision –making process;
- part 4 discusses optimal contract design and monitoring strategies;
- part 5 conclusions

1.2 Risk Management in Operation

Government is responsible for a wide and diverse range of activities including delivering services to the public such as social welfare benefits; procuring and managing major construction projects; regulating industry and collecting revenue. All of these activities involve some form of risks. The Treasury published *Management of Risk - A Strategic Overview* (2000) [1] which defines risk as" *the uncertainty of outcome, within a range of potential exposures, arising from a combination of the impact and probability of potential events.*" Risk management means the public sector has a corporate and systematic process for evaluating and addressing the impact of risks in a cost effective way and having staff with the appropriate skills to identify and assess the potential for risks to arise.

According to the result of survey by NAO in 2000, the main barriers for risk taking in the public sector side are: asymmetric information, risk averse, lack of expertise, lack of formal systems, processes and procedures, unclear responsibilities, the status and activities of public body's limits and time, funding constraints. Instate of tolerating those barriers, the incentives should be incorporated with concessions.

2. Step-in Rights

Step-in rights entitle the public sector to be able to intervene earlier in the event that the private sector is not delivering service to the agreed performance standard .To the extremely circumstance, such a right can be a trigger for the contract termination before contract duration.

2.1 Optimal Time

How often do departments assess overall risks? NAO report (2000) [1] showed thirty-eight per cent of departments do not routinely assess their overall risks. For the private sector entity to undertake such a long term commitment, a further consideration is that priorities change over time and areas of performance subject to assessment need to be reviewed periodically. It is therefore important to identify core areas whose indicators will be collected on consistent basis over time. Later, we shall introduce two financial methods (1) NPV-at-risk method and (2) option pricing theory to identify the critical time issue.

2.1.1 NPV-at-Risk Method

Ye and Tiong (2000) [2] presented the NPV-at-risk method to analyze the impact of the risks on the value of a BOT project. The basic concept of this method is to simulate the primary variables underlying the net present value of a project, and obtain the distribution and confidence level of the NPV. Myers (1976) pointed out the major limitations of the NPV-at-risk method: '*If NPV is calculated using an appropriate risk adjusted discount, any further adjustment for risk is double-counting. If a risk-free rate of interest is used instead, then one obtains a distribution of what the project's value would be tomorrow if all uncertainty about the project's cash flows were resolved between today and tomorrow. But since uncertainty is not resolved in this way, the meaning of the distribution is unclear*.'

2.1.2 Option Pricing Theory

Traditional methods, such as NPV analysis, fall short in reflecting the characteristics of privatized infrastructure projects and the risks involved. Ho and Liu (2002) [3] examined why the evaluation of BOT investments can be improved by applying real option framework and present an option pricing based model for evaluating the project financial viability. So the critical time (bankruptcy condition) can be modeled as

$$V_t - D_t(K_t)e^{-r_d(T-t)} < O$$

Note：

$D_t(K_t)$ is defined as the total outstanding debt at time T prices estimated at time t.

$D_t(K_t)e^{-r_d(T-t)}$ is the total estimated debt at time t prices obtained by discounting $D_t(K_t)$ at the loan interest rate r_d for the period $T - t$.

In order to account appropriately for the asymmetric payoffs under the bankruptcy risk, Equation above suggests that if the project value estimated at t is less than the estimated required total debt at time t prices, the lending bank will force the bankruptcy of the BOT firm to prevent further loss. This quantitative model considers the project characteristics explicitly and evaluates the project from the perspectives of the private sector and of the public sector when the project is under bankruptcy risk. Therefore, the critical time would be pointed out. In that case, the public sector shall have a strong theoretical reason to trigger step-in rights by all means before bankruptcy. Interested readers may refer to Ho and Liu (2002) [3] for details regarding the formulation the BOT-Option Value model.

2.2 Performance Measurement System

In order to trigger step-in rights without discrimination, BOT/PFI contract should contain a reasonable system to measure the private's performance against specified criteria. We introduce two different approaches to explore this issue.

2.2.1 Value for Money

Value for money (VFM) means to achieve the optimum combination of whole life cost and quality to meet customer requirements. Within a VFM framework, evaluation is commonly directed at the following:

- Economy – how much money is spent;

- Efficiency – the relationship between the inputs into activities and the direct outputs from those activities;

- Effectiveness – the relationship between efficiency and outcomes. Outcomes are the ultimate impact of activities and are intended to relate to aims and objectives.

To identify VFM, the illustration between conventional procurement and PFI is showed below (See Figure 1).

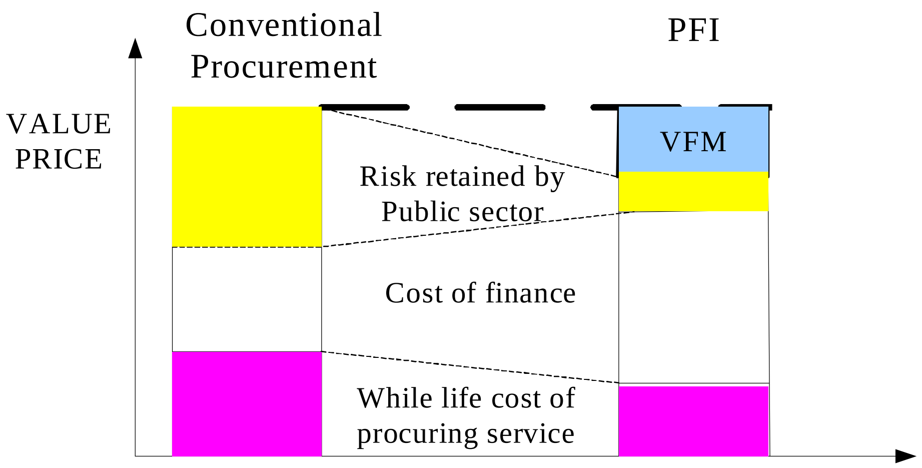

Figure 1. VFM

However achieving cost reductions (or containing costs) does not always represent *good management* – for example if there is a disproportionate, detrimental impact on outputs and outcomes. The transaction cost shall be appraised by including searching cost, bargaining cost and enforcement cost. That is why it is also necessary to evaluate efficiency and effectiveness. Performance Indicators (PIs), for instance, can be used effectively as management tools within an organization to improve the quality, efficiency and effectiveness of museum activities.

2.2.2 Benchmark Approach

Appeals Court Judge Richard Posner, the modern economic law pioneer, pointed out that decisions (judgments) require a benchmark for comparison which implies wealth maximization. Without question PFI's objective shall match the end - wealth maximization. UK experience provided the Public Sector Comparator (PSC) as a benchmark now and it means a benchmark against which VFM is assessed (see Figure 1). The PSC is typically a cost estimate based on the assumption that assets are acquired through conventional funding and that the procurer retains significant managerial responsibility and exposure to risk. The PSC had an inherently high level of uncertainty attached to it, as a result of the difficulty of forecasting not only the demands over 20 years or more, but also the associated running costs and potential income realizable from the project. Risks were modeled in the comparator by using Monte-Carlo simulation and the final output of the final PSC was expressed as a range. The risks modeled in the PSC covered uncertainties in predicting future income in areas such as tickets sand sales and uncertainties in future costs such as ongoing maintenance payments.

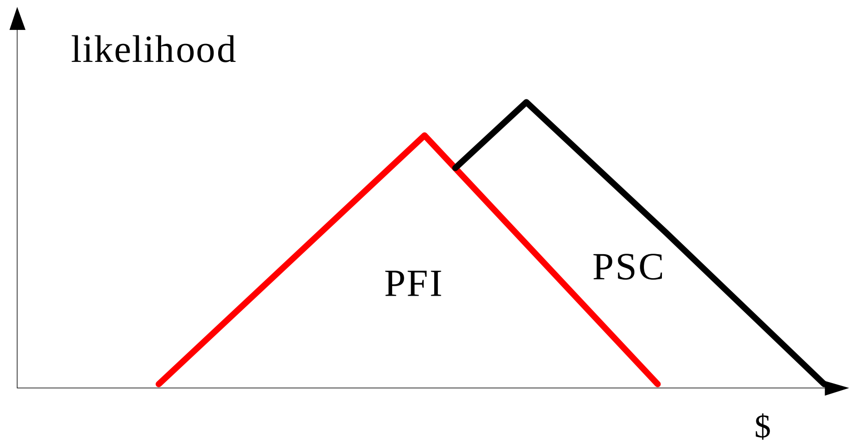

Figure 2 *The Public Sector Comparator (PSC)*

In order to evaluate success, it is necessary to have in mind benchmarks of measuring quality. A key element in this is the perception of value by users. The survey of expenditure may be useful for the private sector to carry out preliminary benchmarking on the relative proportion of expenditure they incur on different types of activity. This may in turn facilitate the gathering and interpretation of benchmarking information.

3. Case Study

The Royal Armouries originally entered into a PFI contract with Royal Armouries (International) plc ("RAI") in December 1993(see Figure 3). Under this contract RAI were to build a new museum which would allow the Royal Armouries to display a greater proportion of its collection. The Royal Armouries agreed to contribute £20 million to the £43 million cost of construction, with RAI meeting over £14 million and Leeds City Council and Leeds Development Corporation £8.5 million.

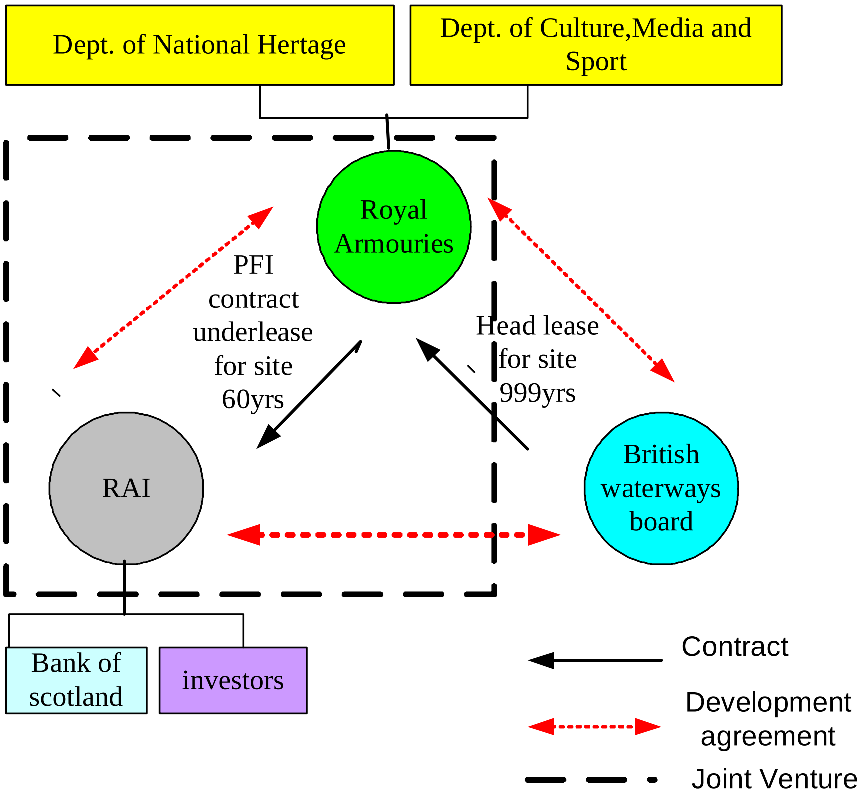

Figure 3 Original PFI Relationship Frameworks in 1993

Once construction was complete, RAI was to operate the new museum for 60 years. (see Figure 4) In return RAI would retain all the income the museum generated from visits by the public. The new museum opened in March 1996; however, visitor numbers were so low that it never made enough money to meet its operating costs and the costs of servicing RAI's debts.

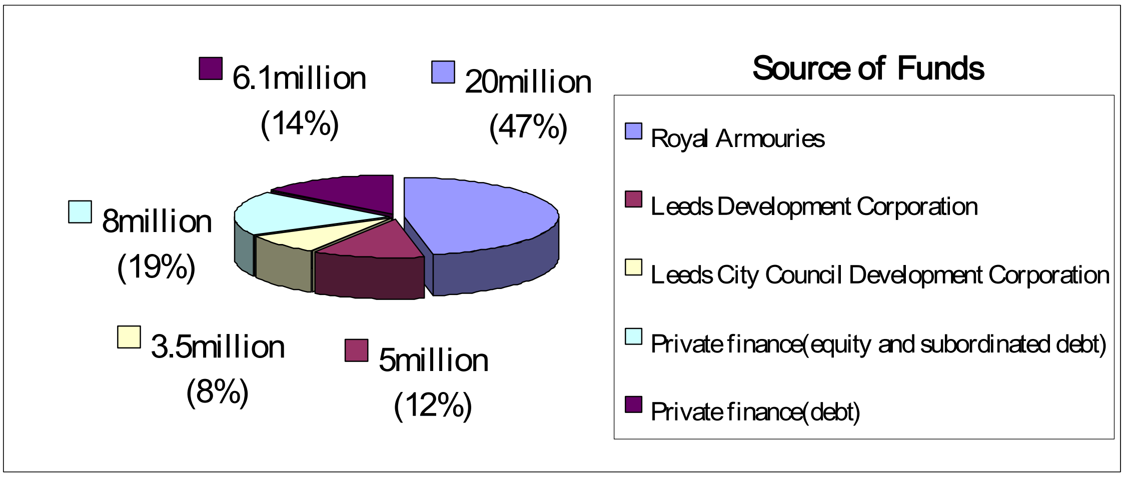

Figure 4 Source of Funds

Consequently, by early 1999 RAI's cumulative losses were estimated at £10 million, despite two refinancing by RAI. As part of the second refinancing in 1998 RAI's bankers, the Bank of Scotland, advised that it would not be able to make additional funding available to RAI after July 1999 if the financial problems persisted. Withdrawal of the Bank's support after that date would have resulted in RAI becoming insolvent. In response, therefore, in July 1999 the Royal Armouries negotiated a revised deal with RAI which ensured that the museum remained open. Under the re-negotiated deal the Royal Armouries took over responsibility for running the museum, while RAI retained responsibility for the provision of catering, car parking and corporate hospitality services at the museum (see Figure 5).

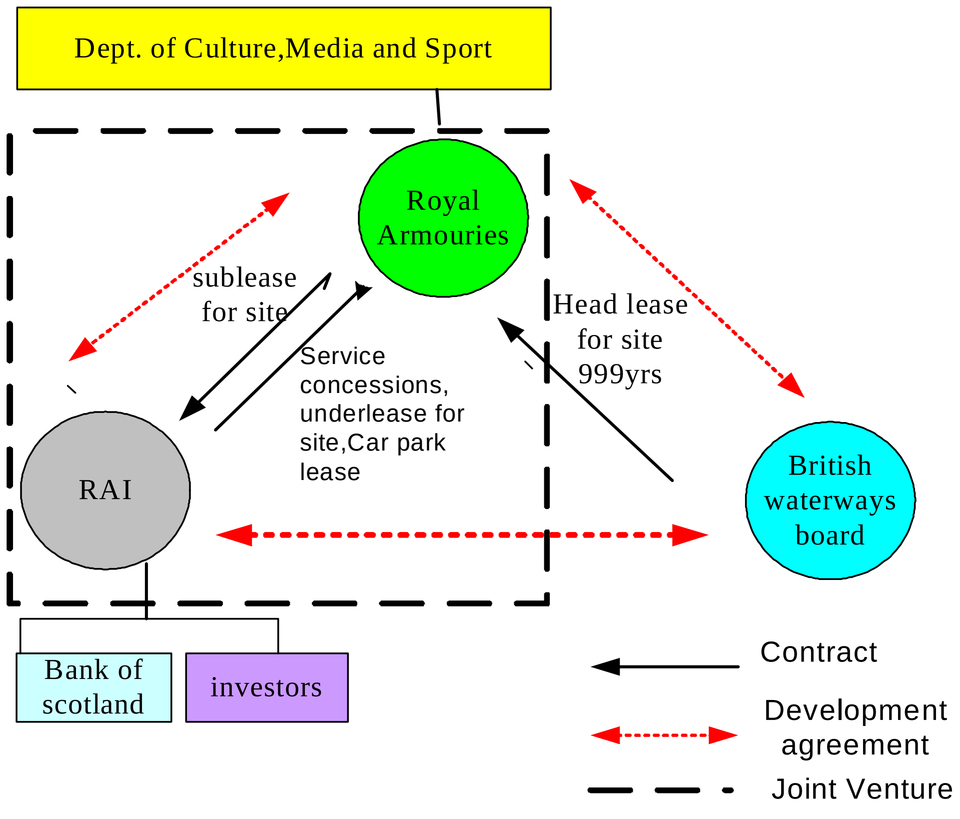

Figure 5 Renegotiation PFI relationship framework in 1999

On the basis of a report by the Comptroller and Auditor General (2000) [4], we explore the public sector's decision-making process by focusing on the forecasts for visitor numbers, the re-negotiation in 1999 and on the extent of risk remaining with the private sector under the terms of the revised deal.

3.1 The Forecasts of Visitor Numbers

The actual number of visitors to the new museum was much less than Royal Armouries and RAI had forecast. However those forecasts were based on a certain pricing assumption and the consultants warned that the actual number of visitors would vary, depending on the admission price charged. The public sector should assess the reasonableness of these projections by comparing them with the performance of comparable existing attractions. In addition, if the project involves a high degree of commercial risk, the project needs to be financed with a high level of risk capital relative to bank debt. If it is necessary to proceed with a project in the absence of adequate levels of risk capital, the government should plan for the contingency that extra funding will be required. The warnings on pricing appear to have been ignored by RAI. RAI had placed over reliance on their own consultancy advice and had charged a high entrance fee of £6.95. One of the first things that the Royal Armouries had done, on taking the museum over in 1999, was to reduce this entrance fee to £4.90.

In addition to the pricing policy, there were a number of other factors which contributed to visitor numbers being less than forecast. Such as delay in the development of the Clarence Dock area surrounding the museum.

3.2 Re-Negotiation an Existing Agreement

Whether the original strategic objectives for the museum had still been met after adopting step-in action？The National Heritage Act 1983 lays down a number of statutory duties with which the Armouries must comply, so the Armouries' objective was to avoid the museum's closure. Obviously, the Royal Armouries did not meet their strategic business objective of becoming more self-sufficient. In contrast, he has taken over the loss making aspects of the museum and will be dependent on extra funding from the government and the income from the lower-than-expected visitor numbers.

In negotiating the deal to save the museum the Royal Armouries did not seek appropriate commercial advice from an insolvency practitioner, although they were faced with a threatened insolvency. Faced with similar situations, the public sector should be clear both about their legal rights and the strength of their commercial position, and be prepared to use those rights and powers aggressively in negotiations. Under the terms of the revised deal RAI had to pay twenty per cent of their turnover to the Royal Armouries once their debt had been paid off. However, there were limits on the capacity of the museum to handle increased visitor numbers. The public sector should ensure that he has the right to share in the benefits of any future windfall gain resulting from any re-negotiated deal.

3.3 Ensuring Risk Remains with the Private Sector

Before signing the contract, the Royal Armouries had taken over comfort from assurances from their financial advisers, Schroders, that the deal was the best available from the market at the time, given the deal's parameters. In considering future deals, the public sector should get impartial advice on the merits of a proposed deal before it is signed. Under the current guidance the public sector would have had to consider at the very start of the project what would happen at the contract's end. On this deal the Royal Armouries' ability to terminate the contract and take possession of the museum due to RAI's insolvency was limited for two years. The public sector needs to consider in advance how they will eventually exit from deals.

There had been a lack of market interest in the deal when it was put out to the market and only one bid had actually been received. The operating specification which was to detail those areas where such co-operation and joint working was required was not agreed subsequently. Even the Royal Armouries were not given access to RAI's financial records and there were disagreements between the two parties over issues which were of fundamental importance to the museum's future. The public sector should be aware of such warning signs that the deal being negotiated will not eventually be sustainable.

Surprisingly the Royal Armouries had no contingency plans in place, as they considered that the risk of the project's failure lay with RAI in the private sector. However, on this deal the business risks ultimately lay with the public sector as the Royal Armouries had been unwilling to countenance the closure of the museum and had therefore stepped in to rescue the project. In considering future PFI projects, therefore, the public sector should consider where the business risks ultimately lie and draw up their own contingency plans accordingly.

4. Contract-designing and Performance Standard

The new museum involved significant commercial risk, as it was a new attraction in a redevelopment area with no proven track record of visits by the public. What gets measured is what gets done. Performance measurement can be used not only to influence behaviour in a desired direction but also to serve as a benchmark. For example, the National Museums and Galleries developed a mechanism for raising standards of efficiency and quality in the sector and to identify examples of good practice. These objectives fit with Government initiatives seeking greater accountability and proof of “Best Value” from public services [5]. Those outputs are as follows

- a Business Model which analyses the activities;
- a long-list of Performance Indicators (PI’s) for each activity;
- An agreed short-list of Performance Indicators to act as the foundation for a performance management regime.

OGC publish valuable reports, guidelines as well as PFI standard form contract [6] which reduce the transaction cost well. What the public sector measure must be meaningful and material to the fundamental mission of the organization and its operation. Strengthening economic legal infrastructure is about improving the quality and accessibility of the law and the capacity of individuals and institutions to implement, apply and enforce those laws. The benefits are:

- improve transparency, predictability and fairness in the rules and regulations and administration of the public sectors; and
- engender business and investor confidence and enhance competition; and

- lead to economic efficiencies, innovation and reduced compliance costs for business

RAI should use the agreed PI's to collect information on outputs and outcomes. Through this they can demonstrate how the museum is contributing to the achievement of government objectives; and The Royal Armouries and the lender should use the agreed PI's to assist with their evaluation of the efficiency and effectiveness of the museum. This will provide an incentive for the private sector to consider where and how to reduce unit costs.

5. Conclusions

The study makes three main types of contribution under consideration:

- introduce an example of current practice;
- consider key issues and critical factors with regard to particular types of BOT/PFI;
- discuss basic standards with which all the private sector should be expected to comply.

In conjunction with investment and facilitation initiatives, strengthening economic legal infrastructure can help deliver significant returns in the form of social outcomes and sustained economic growth. Failure to provide an appropriate standard of decision-making could prove costly as a consequence of market uncertainty and loss of investor confidence. As the issues that need addressing are complex, and in some cases entrenched in legal system, culture and judiciary, measures will need to be undertaken with a long-term perspective, giving rise to incremental but substantive improvements. It is hoped that the work of the study will be continued in the form of an ongoing issues, such as the diversity of the activities, comparability and consistency as well as balancing long and short-term objectives, within performance period by dynamic approaches.

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Section V

Risk Management

CM-at-Risk Delivery System And The Miami Intermodal Center

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Abstract

The Miami Intermodal Center (MIC) is the first "CM (construction manager)-at-risk" project ever funded by the U.S. Federal Highway Administration (FHWA). The size of the project qualifies it for "mega-project" status, but this is not the only thing that makes this an historic project.

MIC, a $2.25 billion project located just east of Miami-Dade International Airport (MIA), is envisioned as a consolidated transfer center for passengers using the airport, intercity and commuter trains, rapid transit, local and intercity buses, and cruise ships in the Port of Miami. The project is being developed by the Florida Department of Transportation (FDOT) and the Miami-Dade Aviation Department, in cooperation with the Miami-Dade Expressway Authority, Miami-Dade Transit, Amtrak, and various rental car agencies serving the airport. The MIC is actually a series of projects, including a consolidated rental car facility, a people-mover connection to the airport, and a number of road access improvements around the airport.

What really makes this project unique, however, is the delivery system chosen by the owners for the early stages of the project. All manner of fast-track construction methods have been used in building construction and industrial construction for years, but these are a relatively recent development in the area of civil, or heavy, construction. FDOT had its first design-build (DB) projects in the early 1990's, with the FHWA beginning to fund DB projects in the state later in the decade. For the MIC, however, the CM-at-risk delivery method was chosen. Very similar to the "Team Approach" taught in construction management textbooks, the CM-at-risk approach is a cost-plus-fee contract with a guaranteed maximum price (GMP). The GMP is based on the sum of the CM's fee, the CM's contingency, the money set aside for General Conditions construction, all the subcontracts, plus an estimate for unbid subcontracts. The CM agrees to pay for costs that exceed the GMP and are not a result of changes in the contract documents.

Keywords: Miami Intermodal Center, CM-at-risk, delivery system, access facility, terminal access roads, MIC/MIA, tri-rail

1. Introduction

The Miami Intermodal Center (MIC) is a world-class mega-project that has drawn intense interest and scrutiny from construction and design engineers both nationally and internationally. It combines the latest in horizontal construction, vertical construction, and project delivery methods. The project scope also includes innovations in project financing and engineering that will be noted, but not discussed at length as they are beyond the scope of this paper.

As early as 1989, the Miami International Airport Area Transportation Study recommendation for the implementation of a multi-modal transportation access facility to help mitigate the growing traffic problem in and around the airport was accepted by Miami-Dade County. However, due to lack of funding and other issues, the project was not started until 2003. MIC will be a world-class multi-modal facility that is estimated to take 15 to 20 years to construct and cost approximately \$2.25 billion.

MIC includes the first transportation project using the "CM-at-Risk" (CMAR) delivery system ever to receive federal funding. All of the work currently scheduled using the CMAR system is slated for Phase I of the project, which is now in progress and is estimated to take five years and cost \$1.35 billion. The work done using the CMAR delivery system includes the rental car facility (RCF), the MIC terminal access roads, and other items, and is estimated to cost \$230 to \$250 million and be completed in 2007.

This paper provides an overview of the project, how CMAR works, and how it is performing when compared to traditional project delivery systems.

1.1 Background

The project sponsor was FDOT, and because of its size and significance, the project was classified as a "mega-project" by the United States Department of Transportation (US DOT). FDOT would act as the "owner" of the project even though Federal Highway Administration (FHWA), Miami International Airport (MIA), Miami–Dade County, and the Federal Aviation Administration (FAA) had a vested interest in the project and could also be considered owners. Once the decision was made to build the project, a consultant, Earth Tech, was quickly added to the team by FDOT as the Program Manager.

Several decisions lay before the team. A designer had to be procured, as did construction engineering and inspection (CEI) services and construction services. A delivery system had to be chosen and numerous permits obtained. The proposed facility had to accommodate the rental car companies around the airport, the Tri-rail system (an above-ground train line that connects the three major south Florida counties—Dade, Broward, and Palm Beach—and ends at MIA), the Miami-Dade County Transit Authority (bus lines), Amtrak, cruiseline courtesy buses, hotel courtesy buses, Greyhound buses, the existing street and highway system, and numerous other transportation entities.

One of the most daunting tasks facing the team was trying to please the numerous parties of interest that ranged from the other involved agencies, such the FAA and Miami-Dade County, to private interests, such as the Tri-rail system and the car rental companies that would use the new facility. In addition, any decision regarding the delivery system had to be filtered through FDOT's long-standing policy that any prime contractor must self-perform at least 50% of the project.

2. The Project

The transportation development portion of the project was separated into two phases. Phase I will include all right-of-way acquisition, access improvements (roadways), the consolidated rental car facility (RCF), the MIA Mover (formerly referred to as the MIC / MIA Connector, this is a two-mile bridge on which either trains or trams will transport passengers between the MIC and the MIA), and the MIC Core (Phase I). Actually, only $80 million of the approximately $400 million cost of the MIA Mover will come from MIC funds, as the MIA Mover is primarily sponsored by the county and MIA. [1] Phase II, not scheduled to commence until at least 2007, will include completing the MIC Core, constructing platforms serving elevated Tri-rail, Amtrack, and Metrorail lines, and all construction of MIA landside facilities.

2.1 Phase I

While the entire program will be completed over the next 15-20 years, the first phase is scheduled to be completed over a five-year period of time at a cost of approximately $1.35 billion. This Five Year Program will consist of the activities and corresponding costs shown in Table 1.

Table 1. MIC Cost Breakdown by Activity Type

Amount	Activity
$ 615,000,000	Construction
$ 350,000,000	ROW and Environmental Remediation
$ 22,000,000	PD&E Study
$ 84,000,000	Design
$ 42,500,000	Program Management
$ 32,000,000	CE&I Costs
$ 93,000,000	Contingency
$ 65,000,000	Financing
$1,303,500,000	Total

2.1.1 Rental Car Facility

The RCF is the first major component of the MIC being constructed. It will co-locate the rental car companies currently located at the airport and many of the companies located adjacent to the airport. The financial impetus for the early commencement of the RCF was a loan from the Transportation Infrastructure Funding Innovation Finance Act (TIFIA). "The RCF is currently budgeted in the MIC work program at $218.7 million; however, a $190 million scope has been agreed to by all parties and an updated financial plan is currently being reviewed by the joint TIFIA Office. When the RCF TIFIA loan is finalized, the work program estimate will be conformed to the project budget. TIFIA loan draws are occurring more slowly than originally forecast and lower TIFIA loan balances are anticipated for eventual repayment." [2] Details of the TIFIA loan are discussed later in this paper.

The sheer size of the building (1400 feet by 1200 feet, with the top floor sixty feet off the ground) makes construction a challenge; however, the size of the building was not the main consideration. Each floor of the building will house a fuel distribution center where gasoline will be pumped into the rental cars at each level. This is the first time that any building in the United States has had elevated fuel distribution capability; special permits and numerous considerations will be required.

The RCF will include:

- Ready/return vehicle capacity of approximately 6500 vehicles
- Fleet storage capacity (vehicles not in use) of approximately 3500 vehicles
- Quick turnaround vehicle fueling and washing facilities
- Spacious customer service facilities for rental car transactions

The most interesting part of the construction of the RCF, and probably the whole project, will be the construction of the elevated fueling centers. The Senior Program Director for the project said that for the period of time that this portion of the RCF is being constructed, "the Fire Marshall will be running the project." [3] This unique construction will be a subject of widespread interest.

2.1.2 MIC Core (Phase I)

The first phase of the MIC Core will cost approximately $80 million and accommodate the bus depot, Tri-rail passenger parking, and MIA Mover Station. The MIA Mover Station will be built adjacent to the RCF. This facility will allow passengers of Tri-rail, city busses, and rental cars to board the MIA Mover, and be transported to the airport terminal. The MIA Mover will feature large cars that run on either electric rails or rubber tires and will be boarded on the top floor of the building, 60 feet off the ground. This facility is expected to be completed and operational by November, 2008.

2.2 Phase II

The transportation development portion of Phase II will consist of completing the MIC Core, constructing platforms serving elevated Tri-rail, Amtrack, and Metrorail lines, and all construction of MIA landside facilities. There is also a commercial development portion of the MIC that will be completed as part of Phase II per the Joint Development Agreement.

2.2.1 Joint Development Agreement

The Joint Development Agreement was first conceived as a revenue-producing program and comprises the commercial development portion of the MIC. An oversight committee was formed to supervise the commercial development, and they retained ERA, a D.C.-based consultant, to perform a study that found that the area in and around MIA was in need of office towers, parking, ancillary retail, and a hotel/conference center.

In early 2002, an RFP was advertised for a developer to handle the commercial development, and the apparent choice is MIC Development, LLC, a joint venture consisting of equity partners The Codina Group and Mallory & Evans, hotel developer The Continental Company, marketing giant Market Place Development, and two large AE firms. Negotiations have begun with this group, with the expected start date on commercial development set for early 2008.

The commercial part of the venture will include office towers, a world-class conference hotel, restaurants, and other businesses. The plans now call for FDOT to lease space to occupants, raising over $5 million per year to help pay the debt incurred through the loans part of the project financing. Appraisals are already being done to estimate the current market value so lease and rental terms can be developed.

A stipulation in the agreement states that if rents exceed $5million in any year, the amount of revenue over $5million will not go to pay down the debt, but must be used to pay for road and bridge construction.

3. Economic Impact

The construction of MIC will result in numerous temporary and permanent job creations within many sectors of the economy, especially construction, retail, and service. It is estimated that over the 15 to 20 years of the entire construction process, 76,000 construction and construction-related jobs will be generated, and 22,000 permanent jobs will be created to operate the facility once it is constructed. The economy and standard of living around MIA will be enhanced because the facility will encourage travelers to use the various public transportation systems integrated into the MIC. It is estimated that by 2010, 75,000 passengers will use the MIC daily. Of these, approximately 45,000 are expected to be using the MIA Mover to travel to or from the airport. [4]

4. Project Funding

Financing the MIC, with a total cost estimated at over $2.25 billion, was a challenge for the state of Florida and Miami-Dade County. Phase I is projected to cost approximately $1.35 billion over five years and has received funding from a variety of sources. While obtaining the TIFIA award brought significant funding, as well as international notoriety to the MIC project, it was certainly not the only significant source of funding. For Phase I, the MIC has received nearly $165 million in Federal Highway Administration (FHWA) grants, $386 million in state

(FDOT) funds, and a $25 million Florida State Infrastructure Bank (SIB) loan. The Miami-Dade Expressway Authority has provided $87 million in toll-backed funding, and the project has also received $18 million from Florida's SIB specifically for a portion of the project, the SR 836/SR 112 connector. The Miami-Dade Aviation Department will fund most of the $400 million cost of the MIA Mover with airport user fees.

The complete list of funding sources and their contribution can be seen in Table 2. [2]

Table 2. Funding Sources for MIC, Phase I

Source	**Contribution ($Millions)**
Prior and future Allocations of State and Federal Funds in Miami-Dade County's Transportation Improvement Plan (TIP), Long Range TIP, and Other State Funding	$249
MIA Capital Improvement Plan	$400
RCF Customer Facility Charge	$25
Miami-Dade Expressway Authority's Capital Program	$86
Miami-Dade County	$30
Ancillary Revenues for from Concessions and Joint Development	$37
FDOT State Infrastructure Bank Loan	$25
TIFIA Loan	$433
Capitalized Interest and Finance Costs	$64
Total	$1,349

Because of the close economic and geographic ties between MIC and MIA, the events of September 11, 2001 led to a reevaluation of the MIC program which focused on funding and timing. MIA has been much slower to recover from the aftershock of the September 11 disasters than most of the nation's airports due to MIA's dependency on passenger traffic from Latin America and the recent effects of low-cost air carriers operating through neighboring Ft. Lauderdale. The project elements most impacted by events since September 11, 2001 are:

- The MIA Mover
- The RCF
- Resultant program schedule adjustments for a delay of 18-30 months.

5. Delivery System

Three delivery systems were given strong consideration for each aspect of Phase I; the result was that different portions of ongoing work are being handled in different ways. Since federal funding was sought for each activity, FHWA approval was required for each delivery system decision. It was decided that portions of the work would be handled in the traditional FDOT way, which is by the linear method, or Design-Bid-Build (DBB). Other portions of the project would be handled by the Design-Build (DB) method.

FHWA had long allowed FDOT to use the DBB method for federally funded projects. FDOT has received federal funding to use the DB method for almost ten years, developing a high level of comfort within FHWA for use of that method in Florida. For the RCF and the MIA Mover

Station, however, a level of vertical construction expertise was needed that FDOT projects do not typically require.

But since the project also contains quantities of earthwork and site preparation common to FDOT projects, and roads and bridges are called for in the project, a delivery system was needed that would best meet the challenge of both linear and vertical construction.

In July, 2000, Earth Tech performed a technical evaluation of three delivery systems as a means for the design and construction of the RCF and certain other related structures. The three systems considered were DBB, DB, and Construction Manager-at-Risk, or "CM-at-Risk" (CMAR). It was decided that this portion of work, amounting to approximately $230 to $250 million, would be let under separate contract, using the CMAR delivery system. Reasons given by Earth Tech for this choice were that CMAR offered the following :

- Design process control
- Ability to meet or exceed schedule requirements
- Highly qualified contractor
- Highly qualified designer
- Budget/Cost control
- Project team formation
- Constructability input from the CM

This choice in delivery systems meant that FDOT had to waive, for this project, their long-standing rule that all prime contractors had to self-perform at least 50% of project work. In addition, in order to receive federal funding, FDOT had to make a special application to FHWA under Special Experimental Project Number 14 (SEP-14). SEP-14 is a program by which FHWA can fund a limited number of projects that don't follow existing FHWA guidelines, provided the projects include innovative construction practices or delivery systems. Until fairly recently, a DB project had to go through this process, but after several successful DB projects, the FHWA stopped requiring this special application for DB projects. The MIC is the first CMAR project ever funded under SEP-14.

5.1 CM-at-Risk

Clough and Sears state in their well-known textbook that, "An appreciable share of the private construction market is now being done using the 'team approach.' When this procedure is followed, the private owner selects the architect and building contractor as soon as the project has been conceived. The three parties now constitute a team that serves to achieve budgeting, cost control, time scheduling, and project design in a cooperative manner." [5]

Using the "team approach," the owner assembles the project's key players, such as the designer(s) and contractor(s), to study the proposed project. The team determines the project scope and budget, and the designer develops preliminary drawings from which the contractor makes conceptual cost estimates. As the process continues, the designer prepares the final drawings and specifications, and the owner makes the necessary financial arrangements. After financial commitments and required permits are obtained, actual construction begins. The designer and the contractor work closely together, modifying the design and the drawings as may be required. The process offers the owner the advantages of time savings, cost control, and improved quality. [5]

The method chosen to facilitate fast-track construction of the MIC, “CM-at-Risk,” is very similar to this textbook description of the “team approach” and can be viewed as an adaptation of this established building construction delivery system used in private industry to civil or heavy construction in a public forum. The CMAR contract is a cost-plus-a-fee contract with a guaranteed maximum price (GMP). The GMP is based on the sum of the CM’s fee, the CM’s contingency, the “general conditions construction,” all of the subcontracts, and an estimate for unbid subcontracts. The CM agrees to pay for costs exceeding the GMP that are not a result of changes in the contract documents.

CMAR theoretically reduces the amount of risk for every entity involved in the project. From the beginning, the client’s (owner’s) understanding of project requirements is combined with the wisdom, experience, and technical expertise of architect-engineer (AE) and CM firms. This team has control over every aspect of the project, and together they provide an absolute directive for design, construction, and functional requirements. One of the most important benefits is that the arrangement fosters a non-adversarial relationship that furthers collaboration in decision making. The CM can review the drawings beforehand and catch errors, reducing the owner’s risk, while the AE similarly reviews the CM’s approach to the work, providing constructive recommendations.

The CM is allowed to take bids or proposals from subcontractors after entering the contract and prior to submission of the GMP, which reasonably reduces the CM’s risk. The procedure is more methodical and more predictable than the low-bid DBB and affords the owner more control over design than the DB system. This is because the AE is under contract to the owner under CMAR instead of being part of a joint venture under contract to the owner and tied to the contractor, as is the case under DB. The lack of a tie between the designer and the contractor reduces the owner’s risk, and in reality, these factors reduce risk for all parties.

There is a contingency within the GMP to cover unexpected but justifiable costs, and a contingency above the GMP allows for owner changes. As long as the subcontracts are within the GMP, they are reimbursed to the CM, so the CM represents the owner in negotiating any changes with subcontractors.

5.2 CM-at-Risk at MIC

The MIC can be seen as a pilot project for CMAR from the FHWA standpoint because it is their first such project. It is also FDOT’s first CMAR project but is not the first for the state of Florida. The Florida Department of Management Services (DMS) has built several vertical projects using the method over the last 15 years. For this reason, DMS had personnel on the original Technical Review Committee and originally had a financial stake in the project because the CMAR contract was forged using DMS procedures. Immediately after the contracts were signed, DMS assigned all their rights to FDOT.

A negotiated fixed fee is the method of CM compensation on the MIC project. The CMs interested in this project had to submit a GMP for administering this fast-track construction project. The chosen CM is required to prequalify all subcontractors and oversee the bidding of all trades contracts. In this way, all construction work would be competitively bid. The only way that the CM could self-perform any construction would be to outbid the subcontractors on a portion of the work.

The CM is paid a management fee plus expenses for oversight and coordination of the construction process. This could include project close-out, systems start-up, as-built drawings, operations and maintenance procedures, and warranty services. The CEI consultant, Earth Tech, performs the QA verification testing, as well as the Threshold Inspection of the building (permit work). The FDOT District Materials Laboratory performs Independent Assurance and Independent Verification testing. The CM, then, is left to perform all QC and Value Engineering (VE) for the project; any savings realized by any VE change proposal is split, with 70% going to FDOT and 30% going to the CM. Earth Tech was awarded the CEI work under a separate contract from the one for their Program Manager duties.

Another contract provision allows the CM to keep 30% of the difference between the GMP and the actual cost of construction. Described by the program manager as “a double-edged sword,” this gives the CM an incentive to keep costs as low as possible, but also presents the CM with the motivation to set the GMP as high as possible. [3]

On January 29, 2001, a legal notice advertisement requesting Statements of Qualification for a CM for this project was posted. Technical Proposals were submitted by the short-listed CMs on May 1, 2001, oral presentations were heard by the Selection Committee on May 24, 2001 and Turner Construction Company was chosen as CM for the project. Delays occurred in getting the project started due to the World Trade Center and Pentagon disasters of September 11, 2001, and when the runner-up for the CM assignment protested the selection of Turner.

After the selection process, FDOT, DMS, and Turner Construction, Inc., signed a contract on March 1, 2003. The GMP No. 1 bid package was issued to Turner on April 4, 2003, and the notice to proceed came in mid-July, 2003. The Organizational Chart for the MIC project is seen in Figure 1.

Construction items were broken down into separate packages called “GMPs”, each to be negotiated separately and each with its own Letter of Authorization (LOA). At this point, the GMP packages are as follows:

GMP I – RCF foundations and underground utilities. Cost: $17.6 million.
GMP II – MIC Terminal Access Roadways (MTAR), Transit Access Roadways (TAR), tunnels, LeJuene Blvd. water main. Estimated Cost: $21.0 million.

GMP III – Tri-rail Station, MIA Mover Guideway Foundation. Estimated Cost: $22.0 million.

GMP IV – MIA Mover Station (minus 4th-floor lobby), RCF Building and bridge. Estimated Cost: $185 million.

The fourth-floor lobby is not currently planned for completion under this project. This raises the possibility of a GMP V, or that the lobby may be constructed under a separate agreement. [6]

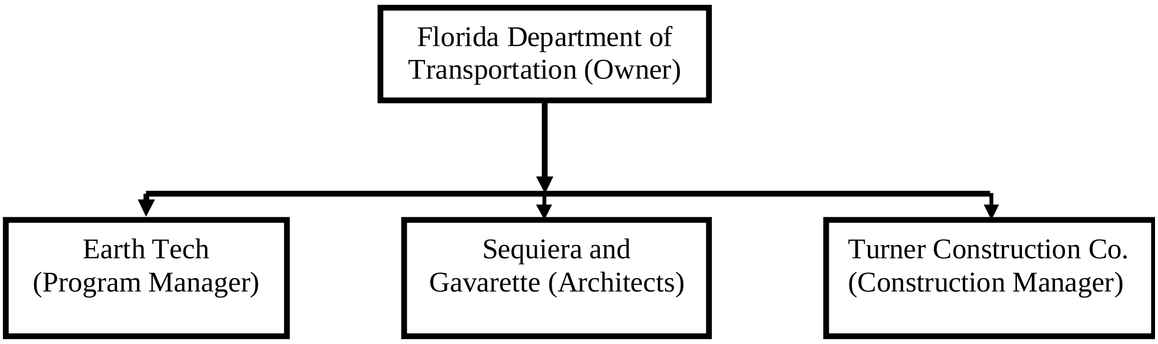

Figure 1. Organizational Chart for CMAR Portion of the Miami Intermodal Center

6. Project Progress

As of the time of this writing, GMP I was completed, GMP II was about 15% completed, Turner had been issued the LOA for GMP III, and the plans for GMP IV were at the 65% review stage. In getting to this point, the CM has overseen the driving of 2779 24-inch-by-24-inch pre-stressed portland cement concrete (PCC) piles, the construction of 672 pile caps, the placing of almost 15,000 cy of grout and approximately 11,500 cy of PCC. Also, over 120,000 cy of fill dirt has been delivered, spread, and compacted and 5000 linear feet of utility lines have been relocated.

Land acquisition and environmental remediation for Phase I and Phase II of the project have been completed. The RCF foundation has been completely constructed, and major roadway projects are under contract. MIA and Miami-Dade County are proceeding toward the procurement of an entity to perform a design-build-maintain for the MIA Mover utilizing advance funds from the county. Customer facility charges have been collected from planned users of the RCF since May, 2004.

7. System Evaluation

Theoretically, the CMAR delivery system brings a wide variety of advantages to a construction project; however, there are important elements that must be in place if CMAR is to bring all of its potential benefits to the project. Two of these essential elements are: 1) The CM must be on board no later than the 35% plans review, and 2) There must be a designer that works especially quickly and efficiently between the 65% plans review and plans completion.

If the CM is not on board by the 35% plans review, then the construction expertise that is so much a part of the CMAR design phase will be lost. In addition, if the designer does not move quickly from the 65% plans review to plans completion, the fast-track advantage will be lost because the CM cannot obtain many of the required permits without completed plans.

Unfortunately, Turner was not brought on board for GMP I until the plans were completed; therefore, there was not the level of constructability review that CMAR is known for. In addition, the project was delayed by the unexpected length of time required for TIFIA loan funds to arrive and was perilously close to being severely delayed by permit acquisition. In both cases, FDOT and the rest of the project team were fortunate. Although 50 change orders were executed in GMP I, resulting in a net cost increase of approximately $600,000, very few of them could have been avoided by a proper constructability review. As for the permits, the project team was again fortunate. The county allowed the RCF to be built under the old (2000) South Florida Building Code instead of insisting it be built under the new (2002), more demanding and time-consuming Florida Building Code, which saved time and outlay equaling at least $5 million. Project personnel estimate that had the authorities not allowed the project to be "grandfathered" into the old building code, the additional delay would have been at least a year. (MIC Personnel 2004)

Another big advantage of CMAR is that, theoretically, there should be a better relationship between the parties to the contract than under the DBB system. While all agreed that this was the case during GMP I, it is apparent that not having the CM on board until plans completion caused things to occur on the project that strained relations to some extent. For example, the CM was forced to act more like a prime contractor than a CM in some of the dealings with the subcontractors because of constructability issues and other questions that could have been solved proactively instead of reactively had the CM been on the team from the beginning. There were also issues between the program manager and the CM early in the process of GMP I that could have been avoided by having the whole team in place from the beginning.

Even with the CM coming on board late in GMP I, the evaluation of the system by the participants was positive overall. Project personnel reported a "great" relationship between the CM and their subcontractors and that there was much less of an adversarial relationship between all parties to the contract than has been experienced under the DBB system.

The difference between working on a project under the DBB system and under the CMAR system was described by one individual on the project as "two different planets. Under the DBB (low-bid) system, all of your profit is made on project changes. Contractor or CM personnel are trained to find potential changes. With CMAR, the CM is responsible for the whole job and the approach to the project is different. The CM under CMAR is much more service-oriented than a CM or prime contractor under DBB. In fact, when this company hires someone out of the DBB environment, it takes an individual about two years to convert from the adversarial attitude bred by the DBB delivery system to the more service-oriented attitude prevalent in the CMAR delivery system.” [3]

Other experiences and insights shared by those involved with the project include:

- The key element in the CMAR system on this project is the contingency fund (10% on this project). Without that, an adversarial atmosphere would appear on the project.
- Instead of the prime contractor or the CM looking for changes as on a DBB project, the subcontractors are doing so, but a strong CM insulates the owner from this problem.
- There was freedom to attract a blue chip contractor (CM), not the low bidder.
- There was much more flexibility and ability to handle the unexpected.
- There was freedom to attract a blue chip designer and pair them with the contractor.
- Much greater ability to handle things that the owner and CM are not familiar with, such as the elevated fueling facilities. [3]

For GMP II, the CM was brought in a little earlier than in GMP I; however, it was not early enough. Turner was brought in only a little before the plans for GMP II were completed but was able to influence the design via the VE process even though they were unable to help at all with the constructability review function. In short, in GMP II, Turner has been more involved in the design than in GMP I but still not fully utilized.

Turner was on board by the 35% plans review for GMPs III and IV. In fact, as of this writing, Turner had just received the 65% plans from which they will calculate and submit a GMP. The intent of CMAR as it is now being administered at MIC is for the CM to assume liability at the 65% plans review, but they have 60 days from receipt of the 65% plans to submit their guaranteed maximum price for any GMP, in this case, IV.

8. Summary and Conclusions

“MIC is a model for infrastructure development and implementation with partners including FDOT, Miami-Dade County (transit, aviation, expressway authority and seaport), US DOT (transit, highways, aviation, and Coast Guard), and various” companies from the private sector. Federal, state, county, and private funding sources are being utilized.

A TIFIA loan has played a critical role in the overall financial structure of the MIC program. It has allowed the parties to commence the project in the most efficient and timely manner and winning TIFIA loan approval won world-wide recognition for MIC.

Although the CM was not involved as early as needed in GMPs I and II, the CMAR system has still performed admirably. The adversarial relationship between owner and CM or prime contractor under the DBB system was greatly reduced even in this incomplete execution of the system. Many of the other advantages credited to the CMAR system were also apparent in the execution of GMP I and, so far, GMP II. Among these are:

- With CM-at-Risk, FDOT has complete freedom to select a design firm completely on the merits of its expertise, reputation, and concept of the project. Similarly, for the construction work, it provides an opportunity to select a contactor with the expertise needed for a particular project and an excellent track record of completing projects on time and within budget.

- Instead of the prime contractor or the CM looking for changes to increase profits, the subcontractors are doing so, but a strong CM insulates the owner from this problem.
- There is a high degree of flexibility and ability to handle the unexpected
- The owner has much more control over the design process than is possible under the DB system

For GMP II, the design was also almost at 100% when the CM was retained; thus, no constructability reviews were provided by Turner. This time, however, Turner did make some contribution to the pre-construction phase by providing VE for some portions of the work.

GMPs III and IV will be more true to the theoretical CMAR because Turner is thoroughly involved in the design and construction activities with input from the beginning through constructability reviews and VE. GMPs. III and IV will, then, provide a more complete case study of the delivery system than the first two GMPs.

Much of the credit for the flexibility and service orientation of the CM and subcontractors was directed at the contingency fund (10% on this project). Without that, it was feared that an adversarial relationship would manifest itself on the project.

FDOT is very pleased, at this point, with its decision to use the CMAR delivery system, and the research team will continue to monitor the project to learn more about the application of this method to transportation construction.

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Poor Quality Costs in the Swedish Central Government Budget: the Influence on Costs For Construction Projects

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Abstract

The poor-quality costs in construction projects are traditionally estimated to 1-10% of the total project cost. These estimations normally include the projects' own processes. However, in Sweden more than 50% of the costs for producing buildings are taxes. To better understand the total poor-quality costs there should also be an analysis of the processes financed by the taxes. This paper aims to map and quantify poor-quality costs hidden in the taxes, here limited to an analysis of the Swedish central government budget. All the expenditures of the budget proposal for 2005 have been classified according to their proportion of poor-quality costs. The preliminary analysis indicates that as much as 28.9% of the expenditures in the public sector are poor-quality costs. This implies that more than 15% of the production costs of an average construction project are poor-quality costs that are hidden in the taxes. A reduction of these costs would enable a tax reduction or an increase of activities to other more essential expenditures in the public sector. Consequently, it will give the customers more value for their invested money.

Keywords: Poor-quality costs, taxes, construction project, public sector

1. Introduction

There are two main reasons to quantify the poor quality costs within processes, which the governments, the county councils and the municipalities take care of.

First, firms and other organizations, which measure poor quality costs, tend to limit their measurement systems to their own processes. In a few cases they also consider their suppliers' processes. In order to be more profitable, they should however, extend the system to consider all dollars, which transfers through the organization and try to find out why the dollars leave the customers' pockets. One starting-point is here that the organization direct or indirect through their actions can influence all these dollars.

Second, in the debate about the high costs for building, the actors argue that the reason is high costs for material, low productivity etc. The Swedish Construction Federation and The Swedish Property Federation argue that the pressure of taxation is too high. They should, however, not focus on the volume of taxation, but the processes financed by the taxes. The social system takes care of many consequences from poor quality within the industry. It would be worthwhile to look closer at what processes financed by taxes could be viewed as poor quality costs and find out how much it influence the costs for a building project.

The specific aim of this paper is to quantify the poor quality costs, which are hidden behind taxes. The analysis, which is preliminary, is limited to the Swedish central government budget for 2005. An underlying practical aim is to present facts, which stimulate the debate about the costs for building and which also stimulate firms and industries improvements. An underlying theoretical aim is to broaden the views about poor quality costs by taking the customers' view, and to stimulate further research within this area.

2. Poor Quality Costs

The theoretical framework for this study is the concept of poor quality costs. For many years the concept of quality costs was used and these quality costs were divided into prevention, appraisal, internal failure and external failure costs, first described by Feigenbaum [1]. Later the term poor quality costs (PQC) was introduced to highlight that it is poor quality that causes extra costs. The focus on the quality methodologies have changed over the years from an inspection orientation, through process control, to continuous improvement, and to designing quality into the product and process [2,3].

The concept of PQC has furthermore been broadened, because the concept of quality has itself acquired a broader customer perspective [4]. The customer is according to Sörqvist [4] viewed as anyone who is affected by the products and the business, e.g. shareholder, financier, state and local government, supplier, user, buyer, company management and employee. Sörqvist [4] uses this broader perspective by dividing poor quality costs into traditional PQC, hidden PQC, lost income, customers' costs and socio-economic costs. Taguchi has also a society perspective when defining non-quality as "the losses of society caused by the product after its delivery" [5].

When the view is broadened to an industry or society perspective, the concept of PQC will include additional activities, which directly or indirectly increase the costs for the customers. The systems used in industry and society may include activities, which can be considered as not adding any value for the customer. For improving the competitiveness it is necessary to develop the concept of PQC a step further and include costs for all other non-value adding activities as well [6]. Of that reason we define PQC as all costs related to poor quality that affect the customers, short-term as well as long-term. Cost is here defined as the value of resources used.

3. Method

We started from The Swedish central government budget 2005 (see Table 1). We looked at the 485 subsidies in the 27 expenditure areas and tried to find out how much could be classified as poor quality costs. For most subsidies that we have not been able to judge how much is PQC, we have assumed that the PQC is 7.5%. This decision is based on literature studies about PQC in various businesses and experience from on-going analysis of PQC in construction-related activities. When it comes to interest on central government debt (expenditure area 26) and contribution to the European Community (expenditure area 27) we have assumed that the PQC in these areas are in the same size as the average for all other expenditure areas.

We have not considered who has caused the costs. This implies that we have seen all costs, which are related to crime and justice as PQC. It also implies that we have seen most costs related to national defence as PQC as well as most costs included in the expenditure area “immigrants and refugees” as PQC.

The analysis is preliminary. It includes a number of assumptions. However, the aim with the paper is to stimulate the debate and make industry people aware that there are major poor quality costs hidden.

4. PQC in the Swedish Central Government Budget

The Swedish central government budget for 2005 is SEK 738.0 billion [7]. Our preliminary analysis indicates that the poor quality costs within the budget is SEK 213.4 billion or 28.9% of the budget. The major costs are related to three expenditure areas: financial security for the sick and disabled, SEK 68.1 billion, defence and contingency measures, SEK 37.9 billion, and justice SEK 22,9 billion, Table 1.

Table 1: Preliminary analysis of poor quality costs in the Swedish central government budget 2005 (SEK million).

	Expenditure area	Forecast	PQC
1	Governance	7840.222	635.071
2	Economy and financial administration	11432.140	1226.938
3	Taxes, customs and enforcements	8803.944	7043.155
4	Justice	27296.871	22868.473
5	International cooperation	1239.582	277.609
6	Defence and contingency measures	44146.606	37933.585
7	International development cooperation	22417.678	4402.850
8	Immigrants and refugees	6933.423	6693.635
9	Health and medical care, social service	39817.525	8335.284
10	Financial security for the sick and disabled	129691.062	68057.398
11	Financial security for the elderly	46413.203	3799.223
12	Financial security for families and children	56356.834	4422.805
13	Labour market	69313.416	12896.106
14	Working life	1193.970	337.555
15	Financial support for students	20995.726	1574.679
16	Education and academic research	43867.639	3290.073
17	Culture, media, religious communities, leisure activities	8956.525	720.656
18	Planning, housing provision, construction	9139.412	746.336
19	Regional development	3496.768	262.258
20	General environmental protection and nature conservation	3994.805	609.406
21	Energy	1396.435	104.733
22	Transport and communications	31666.492	2461.594
23	Agriculture, forestry, fisheries etc.	14655.991	1099.199
24	Industry and trade	3891.377	374.080
25	General grants to local government	57468.750	4310.156
26	Interest on central government debt, etc.	38770.000	11175.870
27	Contribution to the European Community	26802.000	7751.138
	Total, all expenditure areas	737998.396	213409.865

5. The Effect on Construction Projects

The taxes, which the government gets from construction and other industries, puts in the same bag and then distributes to a number of subsidies. This implies, theoretically, that if for example the number of accidents in construction will be reduced there will also be a slightly less tax burden.

The Swedish Property Federation and The Swedish Construction Federation have investigated how much the tax burden is on typical housing projects. Including all taxes and government-related charges The Swedish Property Federation [8] argues that the tax burden is approximately 58.8% of the cost to produce new houses, excluding cost of land. The Swedish Construction Federation [9] takes the analysis a step further and argues that the tax burden may be even higher. The tax burden varies to some extent between different types of products. If we include the cost of land, the tax burden will vary to a greater extent, since the cost of land is significantly higher in the major cities.

Our analysis is limited to the central government's budget while the total tax burden also includes local taxes for municipalities and county councils. Let us for a while assume that the volume of PQC is approximately of the same size within municipalities' and county councils' budgets as it is in the central government's budget. If this is true, the PQC hidden in the taxes corresponds to 17.0% of the cost to produce new houses!

6. Discussion and Conclusions

This paper considers a problem within quality management practices as well as within quality management research. Quality management is built on a customer-oriented philosophy. But when it comes to investigations on quality costs and poor quality costs the customers seem to be forgotten. Instead, the companies' own processes or cash flow is in focus. By taking a customer view in this kind of investigation, a number of hidden costs for poor quality are revealed.

Our analysis indicates that the PQC hidden in the taxes corresponds to 17% of the costs to produce new houses. This is far more than what is reported in most studies of quality costs or poor quality costs within construction. The main conclusion of our analysis is that further studies are needed to better understand the total picture of PQC within construction. Then single companies and single industries better can evaluate what costs related to poor quality can be reduced or not.

Note that this analysis is preliminary and includes a number of assumptions. However, we believe that a closer examination of the central governments' budget, the municipalities' budgets and the county councils' budgets, will end up in a similar size as we have presented here. Since the main aim with this paper is to stimulate the debate about the high costs for building and make practitioners and researchers aware of these hidden costs of poor quality, we believe that this preliminary analysis is relevant and valid.

We have also made an analysis of the central governments budget for 2004 using the same assumptions. Then we found that the PQC was SEK 211.9 billion or 28.7% of the total budget. It means that the PQC within the governments' budget has increased with 0.2% in one year. The main reason is that the budget for the expenditure area "Financial security for sick and disabled" has increased.

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A Risk Breakdown Structure for Public Sector Construction Projects

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Abstract

This research is part of a wider project (ProRIde) focusing on the risk identification stage of the risk management process. The specific remit of the study is to analyse the text of National Audit Office (NAO) reports to identify recurring risk sources on public sector construction projects. A textual analysis software, QSR N6, is used to code the data. The risk source information in organised and presented in a Risk Breakdown Structure (RBS), a hierarchical presentation of risk sources.

The output of this study represents a contribution to knowledge in that it is empirically derived – many risk identification support tools are compiled on an ad-hoc basis through brainstorming or personal experience. This research takes advantage of a rich existing database and employs a systematic methodology to develop an RBS that is specific to the context of public sector construction projects.

Keywords: Public sector procurement, construction, risk identification, risk breakdown structures, QSR N6

1. Introduction

1.1 Overview of the ProRIde project

ProRIde (**Pro**ject **R**isk **Ide**ntification) is an EPSRC-funded project (GR/R51452) concerned specifically with the risk identification phase of the risk management process (see Figure 1). Concurrent studies within the ProRIde project examine risk identification by individual project managers [1] and work is starting on group dynamics.

Comprehensive risk identification is central to the relevance and effectiveness of the subsequent risk management process [2] - unidentified risk sources remain as unknown and unmanaged threats to the project objectives.

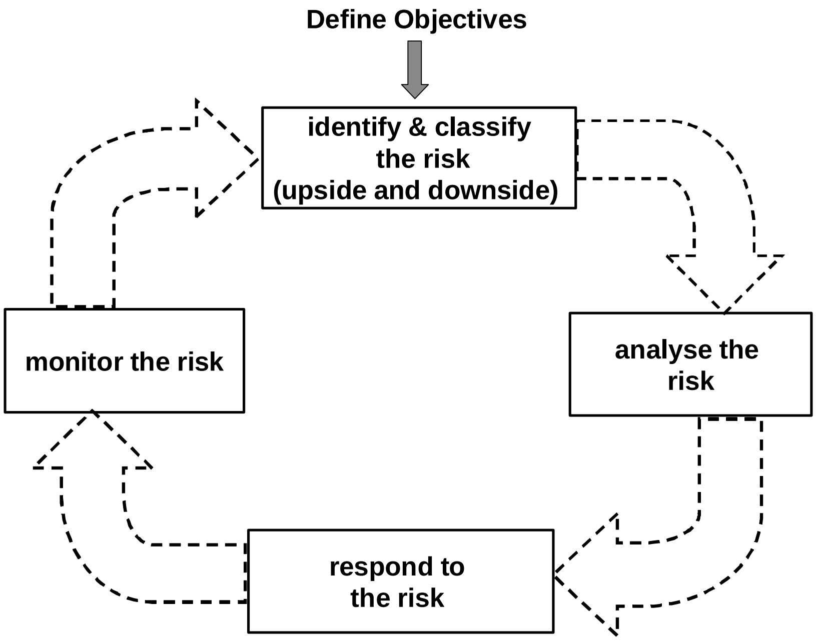

Figure 1: The ProRIde risk management process. After Winch 2002, p.322

Yet the identification stage is relatively neglected in risk management research [3]. There is much emphasis on the risk response stage of the process, with less attention paid to the initial identification and assessment sub-stages. Tah [4] observes that the risk identification stage is omitted from most risk management tools e.g. Monte Carlo simulation and sensitivity analysis, which only operationalise the assessment and analysis phases of the risk management model. Risk identification is assumed to be performed external to, and prior to, the implementation of most risk management techniques.

In the terms of the basic risk management model above, the aim of this study is to produce guidance for the identification phase based on a review of previous projects (the input arrow), leading to improved risk identification performance (the output arrow). High quality risk identification output provides a more accurate basis for subsequent stages of the risk management process.

The ProRIde scoping study [5] identified 'important common causes of concern' in the NAO reports on construction projects. The authors proposed the generation of:

'A feedback loop which offers all parties involved in the management of large, expensive, and complex projects the opportunity to improve efficiency and effectiveness'.

To create this feedback loop, this study takes the individual VFM reports to the next level of analysis. The text of the reports is combined in a knowledge base and reviewed for recurring themes. High-level lessons for risk identification specific to public sector construction projects can be drawn on the basis of multiple projects.

It is important to feed individual project learning in a wider framework so that we develop a systemic approach to risk identification. Ayas and Zenuik [6] note that despite the widespread and successful adaption of project-working, success is usually assessed in terms of a single project or organisation.

Using the past as a guide to future action has obvious limitations. No matter how many project reports are included in review, the final risk breakdown structure can never be considered comprehensive – unpredictable risks will always occur. But while we remain cognisant of this inherent uncertainty, it is important that we take advantage of the information that is available to us. This study takes a pragmatic perspective - reviews allow us to capture a certain amount of useful information and use it as a reference point to improve risk identification on future projects.

2. Risk Identification in the Public Sector

The high rate of failure on public sector projects in terms of time, cost and performance criteria suggests that a review of the Government's current risk management practice is due [7].

Risk identification for large-scale public sector projects is exceptional in terms of its scope and complexity. For example, in a multi-organisational context, as is the case for most government construction projects, it is important to identify systemic risks i.e. 'risk affecting a whole industry or service, as distinct from risks to the position of any individual organisation' [8]. The Office of Government Commerce (OGC) advise organisations to be aware of the risk management approaches adopted by their partners [9]. But NAO findings reveal that only 13% of departmental staff are aware of the risk management systems of other departments or their partner organisations in the private sector [10].

Government priorities also extend the range of risks to be identified. An obligation to secure public value and guarantee service provision means that risks posed by a wide range of external stakeholders and environmental conditions must be considered.

The potential for improving risk identification through project-based learning is limited by the movement of personnel on most public sector projects. Ideally staff would review project performance and record lessons learned centrally. But project personnel are often inaccessible after the event. Baldry [11] acknowledges that the usual method of accumulating past project experience and extrapolating to identify likely risks on future projects is not so straightforward on government projects. Concerted efforts are required to collate historical data due to 'the erosion of large directly employed, professional employee groupings within the public sector organisations' so that experience becomes 'distributed, transferred out or fragmented' (p.38).

2.1 Risk Identification Performance

A survey of risk management performance by the NAO [12] gives some indication of the Government's current proficiency in risk identification. The report highlighted the following areas of concern:

1. Responsibility for risk identification is generally allocated to board level – senior management are responsible for risk identification in three quarters of departments. Only 42% of departments report that other staff are responsible for identifying risks. A dedicated risk manager operates in only 13% of departments (p.57).

2. Departments report using a range of risk identification and risk assessment techniques, including a formal register for recording identified risks and self-assessment questionnaires for staff to record relevant risks. However, only 19% of departments are convinced of the effectiveness of these methods (p.62).

3. Fifty-six per cent of departments report that they identify the main risks relating to their key objectives. Focus group participants reported that 'objective setting and risk identification are treated as two separate processes and these are not routinely linked' (p.55). The NAO recommends that clarifying key objectives in terms of outputs and services facilitates the process of risk identification - departments can 'work back', identifying the risks that pertain to the achievement of these objectives.

4. The NAO warn against 'risk identification overload' – whereby every conceivable risk is recorded regardless of its potential probability or impact. NAO consultation with the private sector indicates that departments should focus on the top 10-15 key risks and opportunities – 'any more than this and management effort can become too diffuse across a large number of less strategically important risks' (p. 87).

5. The internal focus of most risk identification is evidenced by the three most frequently identified risks - financial risk (91%), project risk in terms of time, cost and specification (89%), and compliance risk in terms of failure to comply with regulations (85%). The NAO note the emphasis on departmental inputs and activity - there is less recognition of risk as a threat to outputs and services. The list also illustrates a relative neglect of the importance of external factors e.g. risks relating to external stakeholders.

This corresponds with the assessment of the Strategy Unit [13]. They note that the identification of financial and operational risk sources is relatively advanced on public sector projects. By comparison, the 'systematic assessment of policy risks is much less apparent' (p.46). This pattern of development is reflected in risk management generally – the area of audit / finance risk is most mature, followed by health and safety risk, operational and project risks and finally strategic risk. In relation to strategic level risk, the Strategy Unit states that 'systems still need to be developed that replicate the accountability and responsibility frameworks that exist for financial management' (p.46).

Despite the deficiencies in performance, a review of the available public sector guidance would suggest that Government is at the forefront of risk management – in theory. For example, the Strategy Unit describes the use of progressive risk identification techniques such as futures workshops and horizon scanning by government departments. Another example is the introduction of Risk Maturity Models to measure developments in risk management performance [14]. Also, considerable resources are allocated by Government to research and guidance documents for risk management. But the NAO results suggest that the practice of risk management lags behind the theory. The guidance is in place but it is not consistently implemented.

One reason for this may be a perceived gap between the available models and the conditions of the project in hand. Considerable work may be required to translate the generic guidance so that it is appropriate for individual projects. As such, an objective of this study is to produce a risk breakdown structure that is directly relevant and applicable to the circumstances and events of public sector construction projects.

3. The Current Study

3.1 Data – National Audit Office Value for Money Reports

The NAO is the external auditor for central government departments and all government agencies in the United Kingdom. The Comptroller and Auditor General has the power to report to Parliament at his / her own discretion on how government bodies have used public funds. The NAO presents approximately fifty Value For Money (VFM) reports on government procurement projects to Parliament each year.

The purpose of an NAO investigation and report is two-fold. Firstly, there is the traditional audit function - monitoring departmental spending. Secondly, the NAO has developed a more proactive function - that of adding value to government projects and thereby improving the quality of public service provision. The VFM reports combine both objectives – scrutinising performance against targets while also making recommendations for beneficial change on future projects.

The reports vary in scope, from examination of specific projects to comprehensive surveys of issues and practices across the whole of government procurement. They are primarily concerned with the performance of projects in relation to the time, cost and quality criteria. Reports generally conclude with recommendations for improved practice.

The series of VFM reports constitutes a valuable dataset that has been relatively unexploited to date. This research aims to take advantage of the detailed analysis and unique insights into the operation of complex projects that are available in the reports.

Reports that chart the entire project life cycle of a construction project are included in this study, a total of twenty-five project case histories. To assist the research effort, the NAO supplied electronic versions of all the earlier VFM reports that are not available online. A study of construction projects was perceived to be particularly worthwhile because although the NAO produce an annual report on the performance of major defence projects, there is no equivalent collation of information for construction projects. This is because no single Government department has responsibility for the construction procurement. As such there is no central structure or process for accumulating lessons learned and producing guidance for future construction projects.

Both conventionally procured projects and PFI projects have been included in the dataset. They have been treated similarly in the analysis on the basis that many of the risks to successful project management are generic, regardless of how the project is procured. However, it is anticipated that there will be some variety in the types of risk sources that pertain in each case. When the analysis is complete it will be possible to split the dataset according to procurements strategy to identify idiosyncratic risk sources.

3.2 Methodology – Textual Analysis

This is exploratory research. The aim is to produce a full account of the range and type of risk sources that occur on construction projects, rather than their frequency or impact. A qualitative research method is most appropriate to this objective.

QSR N6 is a textual analysis software, based on a code and retrieve facility. Units of text that are perceived to be connected are coded together into two different types of nodes (see the coding framework in Figure 2 below). **Free** nodes contain text units relating to independent, stand-alone issues. **Tree** nodes contain categories that are related in hierarchies. These nodes make up the coding framework for the project. The option to recode and rearrange hierarchies allows the researcher to change the coding framework as new risk sources emerge and merge. The retrieval function has several aspects. A text search retrieves text from the original document or from selected nodes based on keywords. Various 'Boolean', 'proximity' and other searches permit more complicated retrievals.

For the current research, the value of the software lies in the discipline that it affords the analytic activity of the researcher. In line with Lewins' [15] recommendation - 'it is important to know and to understand your methodological standpoint first, and then to bring a methodology to the software, rather than see the software as being the architect of your method' (p.303). In this study, the software is used as a tool to support a qualitative analysis, guided by an *a priori* organising framework – the risk breakdown structure.

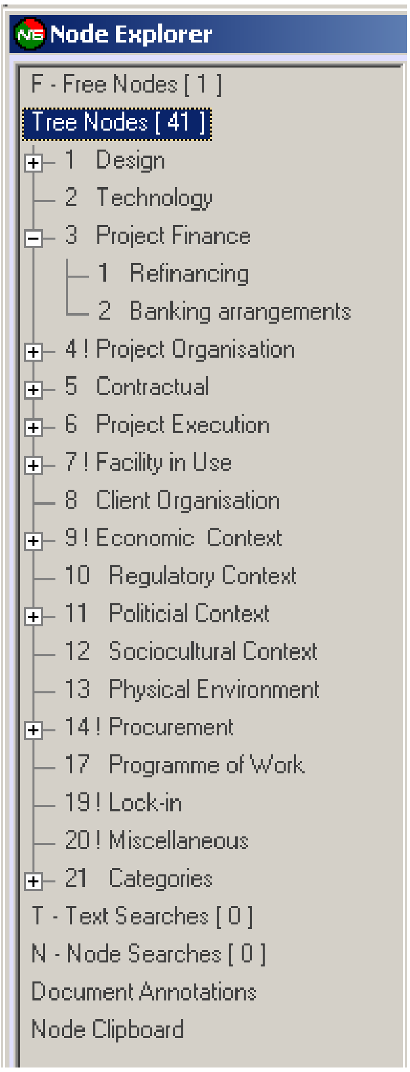

Figure 2: Coding framework in QSR N6

3.3 Organising Framework - Risk Breakdown Structures

An RBS is a framework for organising risk source data. Hillson [16] proposes the following definition:

'*A source-oriented grouping of risks that organises and defines the total risk exposure of the project or business. Each descending level represents an increasingly detailed definition of sources of risk*' (p.2).

Hillson offers a compelling account of the RBS as a means of presenting risk information to aid comprehension and guide the risk management process. It offers a more sophisticated presentation of risk information than the long lists that characterise checklists and risk registers. Checklists are one-dimensional – they do not offer insight into the structure of risk for the overall project. Neither does a list does not represent patterns of risk exposure or highlight areas that require special risk management attention.

An RBS was selected as a suitable organising framework for the current analysis. It provides a structure for the process of extracting and coding risk source information from the reports. An RBS also offers a practical solution for the management and presentation of the numerous risk source categories. An unwieldy list of risk sources can be re-organised and presented more efficiently within a hierarchical framework. There is the further advantage that the RBS and the QSR N6 coding framework share a hierarchical structure. This correspondence facilitates continuity between the data as it appears in the QSR N6 knowledge base and its summary presentation in the RBS format.

Having reviewed the literature, this researcher concluded that no existing RBS was directly relevant to the selected project reports. Therefore, it was decided to take advantage of all the risk breakdown structures generated to date by developing an synthetic RBS based on the range and frequency of existing RBS categories. The method allows the researcher to review, use and synthesise existing results in the research area. Thomas, Kalidindi et al. [17] used a similar technique, to develop an initial list of the primary risk sources on large infrastructure projects in India.

The risk source categories at the various levels of the available risk breakdown structures were collected in an Excel spreadsheet. Similar risk sources were grouped in the same column – this allocation was made when items were considered to describe similar risk areas even if they used different terminology. Some items were re-arranged and column titles were developed during a brainstorm session involving the researcher and supervisor. The resulting synthesis RBS was used as the basis of the coding framework in QSR N6.

3.4 Research Process – Iterative Cycles

A fundamental objective of this study is that the output should be empirically derived, in this case based on a rigorous analysis of the data in NAO reports. Many of the existing tools to support risk identification (checklists, registers and risk breakdown structures) do not have an empirical research basis, but tend to be the product of brainstorming or personal experience.

The research process proceeds in iterative cycles. Five reports are coded and reviewed in each cycle (see Figure 3).

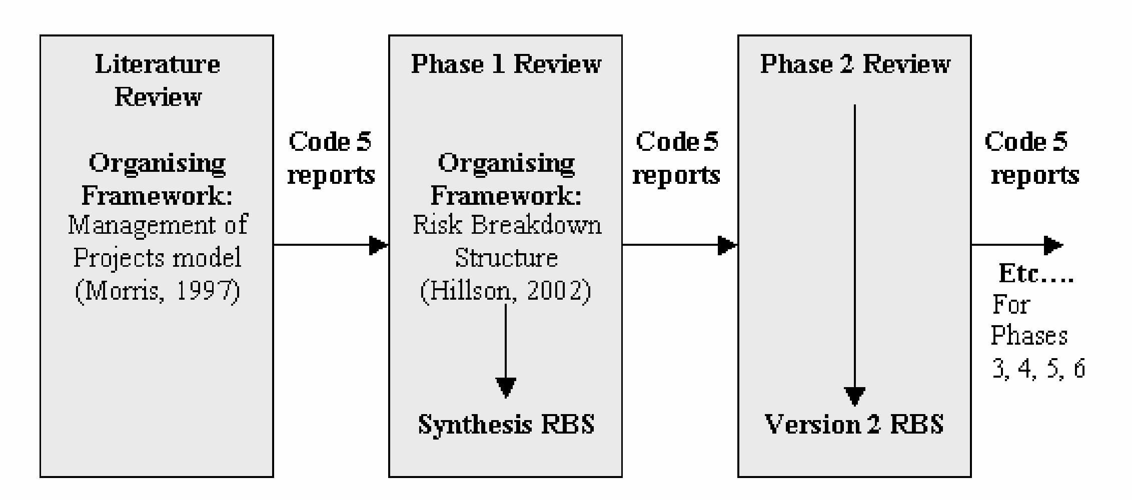

Figure 3. Model of cyclical research process

During the coding stage, the researcher goes through each report, text unit by text unit i.e. sentence by sentence. Text units that are considered to fit with existing nodes in the coding framework are coded into those nodes. Text units that do not fit into any of the existing node categories are temporarily stored in a 'miscellaneous' node.

During the review stage, emerging themes are identified, leading to either the sub-division of the existing node or the creation of new nodes. By this process the coding framework is amended and extended to accommodate those risk sources that are particular to public-sector construction projects. The developing RBS has been presented to NAO staff for feedback at regular intervals.

The cyclical review system also functions as an audit trail – developments in the risk breakdown structure and its underlying knowledge base in QSR N6 are recorded at each review stage.

The final version of the coding framework in QSR N6 equates to the output RBS.

4. Results to Date

4.1 Commentary on Version 5 RBS

To date, twenty NAO reports have been coded and reviewed. One more coding cycle (i.e. five more reports) is planned before the final version of the RBS is complete. This should be available for presentation at the conference in June. In the absence of final results, this section offers a commentary on the progress of the analysis to date.

The latest version of the RBS, Version 5, has developed significantly from the initial synthesis RBS. It contains 231 nodes compared to the fifteen nodes in the original RBS. The hierarchical structure now extends to six levels. In some cases, the nodes contain very few text units. These may be amalgamated with other nodes or removed altogether in the final analysis.

Alternatively, the new nodes may be supported by the next phase of coding, or through the further re-arrangement of text units in the final review phase.

It was anticipated at the outset that the developing RBS would become increasingly sector specific, that is, that the lower levels would refer to the construction context in detail. So far, this is not the case. In a feedback meeting [18], NAO employees agreed that the risk source categories of the Version 4 RBS were sufficiently generic to be applied to projects in most sectors. However, some of the novel risk source categories are specific to the public sector context, such as 'responsibility to the taxpayer' and 'civil estate'.

A cursory examination of the size of the hierarchies attached to the risk sources provides an early indication of risk-critical areas – the 'design', 'procurement', 'project organisation' and 'project finance' nodes are characterised by extensive hierarchies. By contrast, the 'external' risk sources are relatively clear-cut – the hierarchies for 'economic context', 'political context', 'regulatory context', 'socio-cultural context', 'physical environment' and 'programme context' do not extend beyond Level 3 of the RBS. This suggests that factors within the control of the project organisation pose the greatest risk to the completion of construction projects, although this pattern may also be a function of the focus of the NAO investigation. However, the result does correspond with research on the determinants of project success at NASA [19] in which the authors found that external factors, such as legal-political difficulties, are not necessarily 'fatal' obstacles to project success if they are mitigated through effective management of more controllable factors. But the internal factors are more significant - a poorly managed project is most unlikely to be successful. To a large extent the project's capability to deal with the external forces is determined by the quality and effectiveness of the organisational structure, the contract strategy and the financing arrangements, suggesting that it is not the external event that is decisive, but rather how it is managed.

4.2 Evaluation against Research Objectives

The research is on target to meet its objectives:

The analysis is providing a detailed breakdown of the risk sources that occur on large-scale infrastructure projects. Several of the risk sources represent a contribution to knowledge in that they are specific to a public sector context, and have not appeared in previous risk source taxonomies.

The RBS is empirically derived. A sound methodology of iterative cycles has been utilised so that coding is checked and re-checked in the light of emerging themes in the RBS. The method also creates an auditable trail of the evolving versions of the RBS.

The research has harnessed the rigour and discipline afforded by the data management functions of the textual analysis software.

The analysis is retaining the rich qualitative data. Data is stored at several levels of detail - the RBS is a summary of the text units stored in each node (the knowledge base). The original NAO data in each node is available by accessing the relevant node.

Feedback from staff at the NAO indicates that the final version RBS should have potential for further development as a practical risk identification tool. Indeed, it may be useful within the NAO as there is currently no generic risk register available to guide VFM investigations - the issues to be investigated by the NAO are chosen on a project-by-project basis. A comprehensive account of the risk sources encountered on previous projects would facilitate issue identification and provide a context for analysis.

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Factors Affecting the Complexity of Construction Projects

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Abstract

The construction stage is one of the major phases in the life cycle development process of a project. During this stage, it is essential for the project manager to understand and thus to determine the risk elements of the project prior to entering into a construction contract. As the determination of the contract period is crucial amongst other factors, contractors are sensitive to the time factor of a project during tendering. Time/cost trade-offs would be activated whenever the project duration is short. Unreasonably shortening of the contract period may render contractors to pass the risks back to the client through elevated tender prices or contractual claims. A fair allocation of risks can therefore balance the interests of all parties, which is essential for the successful accomplishment of a development project that helps foster a harmony relationship between the project team including the client, designers and other participants. All these ask for a good understanding by the project manager on the project nature, constraints and the complexity of a construction project.

There have been previous works studying the relationship between project durations, contract sums and floor areas, giving a generic understanding about the link between time, costs and volume of work for building projects. However, they do not address the complexity of a project in terms of site production constraints. In this study, apart from the general contract particulars, space-related factors affecting site production are also examined. This study attempts to analyse and identify the characteristics of building projects from the production perspective, aiming at enabling project managers to assess more accurately the project complexity, and thus the risk assessment and analysis for a construction contract.

Cluster analysis will be used to classify building projects into groups of various levels of complexity in a defined level of significance. The characteristics of each group will be reviewed and discussed. The interrelationship between the factors will also be examined. The findings of the study will give project managers some guidelines in assessing the risk factors of a project while the designers or the clients can appreciate the production constraints. A classification system for various levels of project complexity will be developed, with which, a better risk allocation can be made and a more realistic construction duration can be estimated

that help contractors to arrive at a reasonable tender and establish a more efficient production plan.

Keywords: Project characteristic, risk, complexity, cluster analysis

1. Introduction

The construction stage is one of the major phases in the project development process. In managing a development project, it is essential for a project manager to understand and thus to determine the risk elements of the project prior to preparation of the contract documents for a construction contract [1]. The determination of the contract period is crucial amongst other factors. Contractors are sensitive to the time factor of a project in tendering. Time/ cost trade-off would be activated whenever the project duration is shorter than the normal duration or when the project budget is exceeded [2]. Unreasonably shortening of the contract period may render contractors to pass the risks to the client through the tender sum or contractual claims. Lawyers tend to resolve the problems by revising and updating the conditions of contract [3 & 4]. A fair allocation of risks could balance the interests of the parties. This fosters a harmony relationship between the various project parties; namely, the client, designers and the construction team. This can only be achieved if the project manager has a very good understanding of the project nature and constraints.

Studies have been conducted to reveal the relationship between project duration, contract sum and construction floor areas [5]. This can give a generic understanding about building projects. However, it does not address the complexity of a project in terms of site production constraints. In this study, apart from the general contract information, factors affecting site production are included and examined. These include the design of building, forms of structure, building layout, site space and production facilities, etc. This research attempts to analyse and identify the characteristics of building projects at the production perspective. With such understanding, project managers could rate projects in terms of their complexity and are able to develop a fair risk allocation for the construction contract.

2. Appraising the Difficulties of a Project

"How difficult or complex is the project?" This could normally be the first question asked by a project manager or the senior management of a building contractor prior to the preparation of a tender or a production plan. Most construction projects have been commonly described as complex and unique that could not be defined in simplistic terms. This is certainly not a question that could be answered with just a glance at the contract documents especially during the tendering stage. In making decisions during tendering, construction planning, resource allocations and company strategies, detailed information would be prepared for scrutiny by the senior management. The critical information for a construction project will include the estimated contract sum, contract period, floor areas, building design, any special features and site conditions. However, such generic information may not be able to depict the complexity of a project and it would be worthwhile to analyse and integrate these information to develop an overall picture to reveal the project characteristics.

Facing with the time constraint in tendering and pre-contract planning, it is common for senior managers to make decisions largely based on two or three attributes of a project from a macro perspective. “Contract sum”, “construction period” and “construction floor areas” are the typical primary information to build up the decision tree. These attributes can depict the scale of a project and were thought to be good indicators for describing the complexity of the project. However, they cannot explain the difficulties or the constraints on production planning; for example, a small scale project classified in terms of the contract sum can give misleading results if the site is very confined without sufficient working space and good access. Supervisory staff at the production frontline always expresses their resentments about the oversimplification by the senior management in defining the project scope and inadequacy in resource allocation. The allegations are based on the fact that senior management may allocate the manpower and site facilities, including plant and equipment in a pro-rata scale based on the contract sum and construction floor areas.

There were some researchers studying the facility layout problems aiming at optimizing the site space at operational level [6, 7, 8 & 9]. Contrasting with them, this study aims at providing a better understanding in the classification of building projects, and thus to improve decision-making with respect to site production planning at the contract planning stage. Apart from the aforesaid attributes, seven factors will be identified, which can be extracted from the project data for analysis.

3. Factors Affecting the Complexity of Building Production

Information of 30 high-rise building projects have been collected to examine the validity and the robustness of the aforementioned three primary project attributes and another seven space-related attributes in describing the complexity of a project. These projects are widespread in size in terms of contract sum, site area and gross floor areas. Also, they consist of public housing projects, private residential projects, commercial building projects and composite developments. Table 1 shows a summary of descriptive statistics of the projects.

Table 1 Summary of Project Information

Variable	Cases	Mean	Std. Dev	Maximum	Minimum
Contract Sum	30	672.18	574.74	3000.00	41.00
Contract Period	30	26.17	4.91	37.00	18.00
Gross Floor Area	30	97106.13	73611.52	315990.63	5289.20
Site Area	30	12871.37	12523.97	67790.54	448.26
Podium area	30	5907.87	5515.91	26796.09	448.26
Tower block area	30	2794.21	2114.78	8253.34	179.29
Number of building	30	3.37	2.43	12.00	1.00
Working Space	30	6946.78	8456.72	40994.45	0.00
RWSPBA	30	2.32	1.92	8.40	0.00
RTWSPSIA	30	0.52	0.24	0.93	0.10

Where:

(i) Contract sum denotes the contract price or estimated construction budget (in millions of dollar)

(ii) Contract period denotes construction time for the construction of superstructure (in months)

(iii) Site area denotes the total site area falling within the site boundaries (in square meter).

(iv) Gross floor area denotes the total construction area (in square meter)

(v) Podium area denotes the total floor area of the podium of a building or buildings (in square meter)

(vi) Tower block area denotes the total areas occupied by the buildings above the podium floor (in square meter)

(vii) Number of building denotes the total number of buildings to be constructed

(viii) Working space denotes the site area not occupied by the permanent structures (in square meter)

(ix) RWSPBA denotes the ratio of working space to the tower block area (in square meter)

(x) RTWSPSIA denotes the ratio of working space to the site area (in square meter)

Variables in relation to site space, which are critical production constraints, are introduced in the analysis. In building production planning, the site layout plan represents the production line set-up of a factory. In formulating the site layout plan, it is necessary to balance the space requirements for different site activities. However, if space is more than adequate to meet the demand of the production process, there is no need for the trade-off exercise and it becomes largely a space allocation problem [10]. For example, if heavy building materials or components can be stored within a large storage space with good access for delivery and unloading which can be reached by a tower crane, production planning is a simple exercise to minimize the hoisting time for transferring the materials from the storage position to the work place. However, a site with irregular configuration and insufficient space, it is necessary to trade-off the storage areas for different materials or components, the schedule for the installation processes, the storage areas and the access roads. The inclusion of the space related variables gives a more accurate assessment on the complexity of projects in the context of production management.

As shown in Table 1, the seven space-related variables describe the areas to be constructed and space availability for a project. In addition to the gross construction floor area, the floor area of a tower block and the area of the podium supporting the tower blocks are included. In some extreme cases, the podium area could occupy 90% of the site area. However, the building structures sitting on top may occupy just 40% of the site area. In order to reflect the relationships between these variables, two ratios, namely the RWSPA and RTWSPSIA, are derived to assess the adequacy of site space.

4. Classification of Building Projects

It is often difficult to define the nature and complexity of a project and construction management people always use the following terms to differentiate the characteristics of a project: large, small, medium, simple, difficult, complex, complicated, highly integrated, confined, unique, etc. The use of these semantic terms can give some inference to the basic constraints of a building project; namely time, cost, quality and space, and is simple and easily understood by readers. The disadvantage is that it could be misleading to depict the complexity of a project.

In order to derive an objective classification system for projects, cluster analysis techniques, which have been widely used in areas of marketing, biology and medicine are adopted in this study [11]. To start, building projects are reviewed, classified and verified by using SPSS Hierarchical Cluster Analysis (HCA), K-Means Cluster Analysis (KCA) and Discriminant Analysis (DA). The projects are firstly classified by using the HCA and then verified by KCA and DA. The use of DA can establish classification function coefficients for classifying future projects. Further, the study attempts to compare the classification generated by using the three primary variables and subsequently by all the ten variables.

The objective is to classify the projects into groups with distinguishable characteristics. The analyses aim at dividing the project samples into five groups using the concepts of natural classification without limiting the number of group membership. This would facilitate the project mangers to describe the project definition [12].

4.1 Initial Appraisal for Building Projects

The first attempt is to compare the classification derived by using general project information, namely contract sum, contract period and gross construction floor areas. Table 2 shows the membership of the projects classified by using the general project information. Tables 3 and 4 show the characteristics of the groups in terms of minimum and maximum values of variables for the groups.

4.2 Classification by Contract Sum

In the groups classified by contract sum, the resultant groups are ranked in ascending order. Apart from Group 1, the subsequent four groups have a similar range with the group boundaries between 137 million and 183 million. Although the classification would be affected by the data in the analysis, it is reasonable to observe that the classification is similar to the conventional semantic description for a project in terms of large, medium and small.

4.3 Classification by using Three Basic Project Variables

In the classification using the three basic project variables, the groups overlap in the ranges of contract sum. It becomes inappropriate to describe the projects by using the conventional semantic terms. The characteristics of the groups are governed by the interactions between the variables which can be explained by the group characteristics and the classification function coefficients shown in Tables 4 and 5 respectively. The following characteristics are observed:

1. Groups 1 and 2 – These two groups have similar characteristics with negative coefficients for contract sum and gross floor area. It means that the contract sum is less significant to describe the project. On the other hand, the contract duration is the dominant factor and covers a broad range of 18 to 34 months. From the observations, it may reasonable to state that projects of small to medium size in terms of contract sum have significant difference in project duration, which is relatively longer than projects of other groups. It may infer that the time factor for these projects is not critical.

Table 2 Classification for building projects

Project Reference	**Classification Variable**		
	Contract sum	**3 Basic Project Variables**	**Basic & Space-related Variables**
1	1	1	4
2	1	1	4
3	1	1	4
5	1	1	3
8	1	1	4
9	1	1	3
11	1	2	4
14	1	2	4
17	1	1	4
25	1	1	4
27	1	1	3
4	2	2	4
6	2	3	4
10	2	4	2
15	2	2	4
21	2	3	4
22	2	3	1
23	2	4	2
29	2	3	2
7	3	3	4
18	3	3	1
24	3	4	4
26	3	4	5
28	3	3	1
30	3	3	3
12	4	5	5
13	5	4	2
16	5	3	1
19	5	3	1
20*	x	x	x

*Project 20 contains extreme data and was excluded in the classification.

Table 3 Classification of projects by contract Sum - Group Characteristics

	in million $	
Group	**Min**	**Max**
1	41	400
2	497	680
3	740	877
4	1000	1179
5	1756	1756

Table 4 Classification of projects by contract sum, construction duration and gross floor area - Group Characteristics

	Contract Sum in million $		Contract Duration in months		Gross floor area in meter square	
Group	Min	Max	Min	Max	Min	Max
1	41	400	18	25	5,289	70,708
2	200	500	28	34	24,297	157,776
3	577	1070	22	26	58,436	235,115
4	500	1179	30	36	91,132	176,996
5	1756	1756	37	37	217,501	217,501

Table 5 Classification of projects by contract sum, construction duration and gross floor area - Classification Function Coefficients

	Group				
	1	2	3	4	5
CONTSUM	-0.0061	-0.0048	0.0098	0.0032	0.0356
CONTPERD	4.8732	6.8313	4.8786	6.7053	7.1917
GFA	-0.00000407	-0.00002373	0.00002566	0.00002750	0.00001834
(Constant)	-54.9755	-106.9848	-65.6303	-111.9356	-167.9171

2. Group 3 - The contract duration is still the dominant factor whereas the coefficient for contract sum is positive and thus has more influence on the classification. The range for project duration covers a relatively narrow range between 22 and 26 months. Further, the gross floor area has a positive influence on the classification and covers a broad range of 58,436 to 235,115 square meters. It may be reasonable to state that the projects of this group which are conventionally described as medium to large size generally having a relatively tight project duration and with a high variation in the work contents in terms of gross floor areas.

3. Group 4 - the contract duration has imposed further influence on the classification and the contract sum and gross floor area have similar influence on the classification as in Group 3. It is observed that the range of contract sum of 500 to 1179 million for this group is similar to the range of 577 to 1070 for Group 3. However, the project duration for these projects has a relatively longer duration between 30 to 36 months.

4. Group 5 - There is only one project which is the same as that in the classification by contract sum. This project is unique amongst other projects in terms of contract sum, contract duration and gross floor area. The project can be described as mega size and thus needs to be considered separately.

The project classification generated by the basic project information provides further understanding about the nature of the project and could enable project managers to identify the dominant factors of a project especially on the time factor. On the other hand the classification reveals that there may be imbalance for project duration as it appears that projects in Group 3 have a relatively tight project schedule. This would be a good reference for clients or the design teams for determining reasonable project durations.

4.4 Classification by Using Basic Project Information and Space Related Variables

With the inclusion of seven space related variables, the governing factors for the classification becomes complex and is significantly different from the previous classifications. The characteristics of the groups and the coefficients of the variables to the cluster centre are shown in Tables 6 and Table 7 respectively. The characteristics for the groups are discussed below.

1. Group 1 – Site area and the site space are the dominant variables in this group. In view of site planning, these projects have sufficient space for site layout planning as the ratio of working space to building area, between 2.21 and 5.54, is the highest among the other groups. The negative coefficient for project duration implies that time may not be critical in this group. The scale of the projects in terms of contract sum is between medium to large size. With sufficient working space and reasonable project duration, it may conclude that there will be less constraints, more flexibility on site layout planning and project scheduling.

2. Group 2 – Contract duration, gross floor area and the ratio for total working space and site area are the dominant variables in this group. The range for contract duration is between 24 and 36 months and gross floor area is between 101,838 and 146,068 square meters. Although the work contents for the project is high as reflected also in the contract sum, there are relatively less working space, between 1.76 and 3.38, in this group when compared with Group 1. The significance is shown by the high coefficient assigned to the space ratio. Projects in this group would therefore have a reasonable project schedule but with moderate difficulties in site planning.

3. Group 3 – Space related variables have large coefficients and become significant in this group whereas the contract duration has a large negative coefficient. Comparatively, both the scale and the contract duration are moderate in this group. But, the working space available is high for the projects as reflected in the ratio of working space to total floor area, from 1.68 to 5.11. With the sufficiency in working space, production planning for the projects would not be too difficult.

4. Group 4 – This group, which has the highest number of members, consists of 14 projects. Except for the contract duration, all the variables are assigned with negative coefficients. The contract duration varies between 22 and 34 months. This may be due to the broad range of contract sums, from 41 to 870 millions. The projects can be described as small to medium size. However, the total site areas for the projects in this group are small when compared with other projects and thus, the working space to

building area ratio is low. Therefore, these sites can be classified as confined site and there will have more constraints on site layout planning and production planning.

5. Group 5 – There are two members in this group. They are high-rise buildings with tower blocks sitting on a large podium area. They are large projects with high contract sum, long contract duration, and high work contents (gross floor areas). However, there is limited working space as reflected in the working space ratio (0.5 to 0.54). The sites are therefore highly confined with small working space for production planning. Project scheduling and site layout planning for these projects should be well co-ordinated so as to optimize the use of site space for supporting work schedule. Multi-stage site layout planning is expected in such site conditions.

The project classifications generated by the basic project information and space related variables provide different views on characteristics of the project and give more information about the relationship between the contract size, work contents and work space. Although the order of the grouping may not be able to determine accurately the complexity and difficulty of the projects, the classification is able to alert planners about the potential constraints on production planning in relation to project scale or project duration. The characteristics and the degree of complexity of the projects are summarised in Table 8. The indications on production complexity also enable contractors to improve risk assessment for construction projects.

5. Conclusion and Recommendations

In this study, apart from the general project information, factors affecting site production are also examined in the evaluation of project complexity and nature. This study attempts to analyse and identify the characteristics of building projects from the production perspective, aiming at enabling project managers to assess more accurately the project complexity and the project risks. With a good risk planning and risk allocation, this would mitigate contractual disputes [13].

The classifications generated in this study have successfully grouped the projects in terms of basic project information and space related variables. This study provides a new approach in analysing the interactions between the ten critical project variables. It is observed that the memberships for grouping are significantly different. The classification by using the three basic project informations reveals that there may be imbalance for project duration with respect to the contract sum. With the inclusion of the seven space related, there are significant changes in the memberships for the project groups. The resultant groups are more able to address the complexity of a project. The ranking of the project groups is able to indicate the degree of project complexity. Practitioners may apply a heuristic approach in classifying projects in similar ways. But, it may be difficult to rank the complexity accurately and consistently. This study provides a systematic approach to determine the complexity of projects with reference to the interactions between the ten project variables. The information would alert and be useful for planners to assess the risk and complexity of projects. Specific attentions would therefore be given for projects with confined site space, tight schedule and high work contents.

Apart from the variables selected, there are other project variables which could be used to assess the complexity of a project. It is suggested to explore these variables in order to build up robust models to improve the classification and to determine the risk level of a project. The findings described in this paper provide a stepping stone for future in-depth studies on project risk and contract planning.

Table 6 Classification of projects basic project information and space related variables: Group Characteristics

	Range	CONTSUM	CONTPERD	GFA	SIA	PODA	TBA	BNO	WSPA	RWSPBA	RTWSPSIA
1	Max	1070	26	235115	25155	5735	5735	7	19480	5.54	0.87
	Min	680	24	137628	16660	3441	3441	3	11475	2.21	0.69
	Diff	390	2	97487	8495	2294	2294	4	8005	3.33	0.19
2	Max	1179	36	146068	12886	6515	3441	5	9445	3.38	0.90
	Min	500	24	101838	10416	3251	2214	3	3901	1.76	0.53
	Diff	679	12	44230	2470	3264	1227	2	5544	1.62	0.37
3	Max	877	22	90500	22499	14043	5028	5	8456	5.11	0.93
	Min	315	18	38522	8760	2408	1139	2	5117	1.68	0.39
	Diff	562	4	51978	13739	11635	3889	3	3339	3.43	0.54
4	Max	870	34	91132	9301	7855	6135	4	4620	4.03	0.78
	Min	41	22	5289	448	448	179	1	0	0.00	0.10
	Diff	829	12	85843	8853	7407	5955	3	4620	4.03	0.68
5	Max	1756	37	217501	18912	15662	8253	7	4162	0.54	0.38
	Min	790	33	176996	18660	14750	5503	4	2998	0.50	0.16
	Diff	966	4	40505	252	912	2751	3	1164	0.04	0.22

Table 7 Classification of projects basic project information and space related variables: Final Cluster Centre Coefficient

Variables	**Group**				
	1	**2**	**3**	**4**	**5**
Zscore(CONTSUM)	0.719	0.353	-0.298	-0.531	1.808
Zscore(CONTPERD)	-0.378	0.750	-1.315	0.045	1.758
Zscore(GFA)	1.183	0.671	-0.452	-0.733	1.737
Zscore(SIA)	1.425	0.120	0.460	-0.831	1.093
Zscore(PODA)	-0.011	-0.265	0.673	-0.478	2.554
Zscore(TBA)	0.941	0.096	-0.081	-0.621	1.965
Zscore(BNO)	1.055	0.372	0.235	-0.740	1.328
Zscore(WSPA)	1.831	0.342	0.119	-0.729	-0.392
Zscore(RWSPBA)	0.969	0.309	0.663	-0.479	-1.016
Zscore(RTWSPSIA)	1.005	0.820	0.198	-0.505	-1.013

Table 8 Characteristics of projects classified with space related variables

Group	Contract Sum	Project duration	Site Space	Production Complexity
1	Medium to Large	Medium	Large	Low
2	Small to Large	Long	Small to medium	Average
3	Small to medium	Short to medium	Small to Large	Moderate
4	Small to medium	Medium to long	Small to Medium	Intricate
5	Medium to Very Large	Long	Small	High

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Risk Management in Small Sized Construction Projects

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Abstract

Risks and other uncertainties can cause losses, which lead to increasing costs and time delays, both during the project and at the end. The need to prevent failures during the construction process and other losses related to construction has been emphasised in various reports. Example consequences are failure costs in civil works which can be close to 8% of the total budget for projects – more than 60% of these are costs due to 'self-inflicted' uncertainty. However, this paper is focused on small sized construction projects (in the range 1-15 MSEK), which are dominant in the Swedish construction sector today. They account for 83% of the total number of projects.

The aim of this paper is to describe how risks and uncertainties are managed in small sized construction projects. Some characteristics of these projects are presented, for example their organisation, financial size and type of contract undertaken. The paper identifies and describes the ways in which risk analyses are performed on a number of small projects today and where the common risks are believed to lie. The study is based on interviews with personnel selected from a number of construction companies. In order to be able to make improvements in the construction sector, a clear focus on uncertainties, which means both opportunities as well as risks, is needed. Organisations working mainly on small projects, that wish to improve their performance, need systematic methods for managing risks.

Small sized construction projects are found to be managed both intuitively, i.e. based on experience and systematically, i.e. using methodologies for risk and uncertainty management. The systems are, however, developed with the intention of fitting all sizes of projects and not specifically small sized projects. Some common risk sources in these projects are contract documentation and tight schedules, the client, individual planning and logistics, cost estimates used to compile the tender, subcontractors, technical solutions, safety of third parties and weather.

Keywords: Risk, uncertainty, risk management, uncertainty management, small projects

1. Introduction

1.1 Background

Risks and other uncertainties can cause losses, which lead to increased costs and time delays, during the currency of projects and at their end. The need to prevent failures in the construction process and other losses relating to projects has been highlighted many times over the years and figures strongly in a recent major report in Sweden [1].

The most common project size in the Swedish construction sector is less than 15 MSEK (roughly €1.65m). In the study reported in this paper, projects in the range 1-15 MSEK have been chosen, whilst those in the range of 0-1 MSEK have been excluded. According to Sveriges Byggindustrier [2], as much as 83% by number of projects are in the range of 1-15 MSEK. The reason for choosing this particular segment is that the smallest projects, the ones between 0-1 MSEK, are less interesting from a project risk management perspective. Their nature is inherently more like continuous business than project-based.

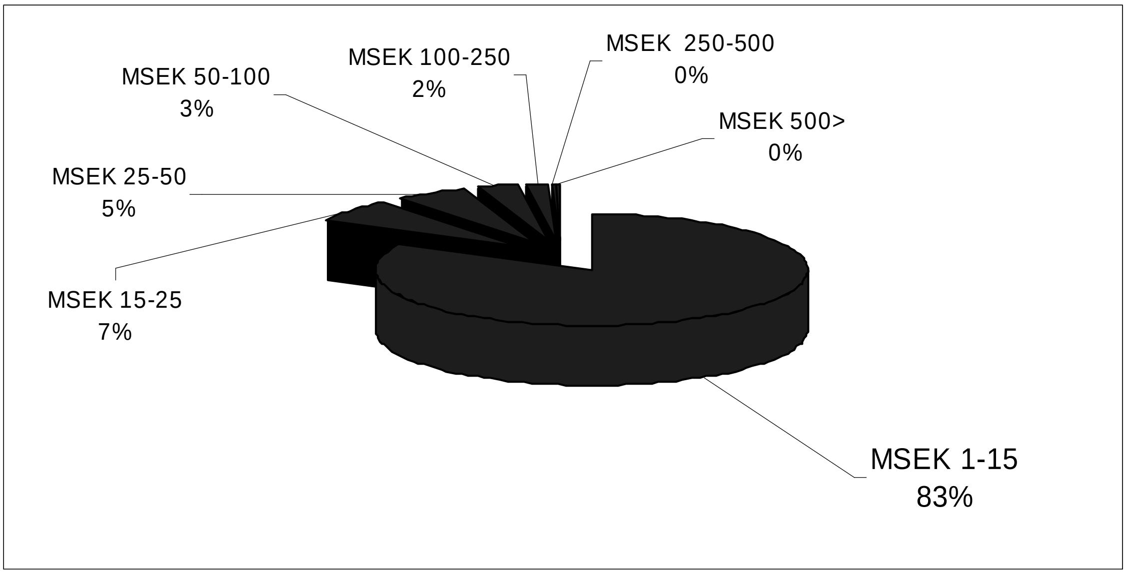

Figure 1. Number of projects divided into segments in relation to their size in the Swedish construction sector 2004.

Risk management and other types of applied management have been used routinely in construction projects, but have often been exclusive to large and exposed projects. Studies tend to cover large-scale projects, often with many different participants [3], [4] and [5]. The risks cover a spectrum of events from financial, political and legal to technical, often relating to complex construction.

In one study [6], failure costs for civil works were identified as being close to 8% of the total budget for projects and more than 60% of those costs were due to 'self-inflicted' uncertainty. The study also focused on large projects and clients' perspectives. 'Self-inflicted' uncertainty is due to ignorance of earlier experience of failures that continue to appear in similar projects in the future.

In small sized projects, the risks are more moderate and the consequences are less dramatic. These projects are more vulnerable to changes of the kind that have an impact on time since there is less chance of catching up if the schedule slips. On the other hand, the nature of the construction work and the project environments are often rather straightforward and the technical challenge is limited. This picture of the situation for small sized construction projects is based on the author's own observations and that of the study's reference group.

1.2 Aim and Objectives

The aim of this paper is to describe how risks and uncertainties are managed in small sized construction projects. Three specific objectives have been set as follows.

- Present the characteristics of small sized construction projects.
- Describe the ways in which the risk analyses are performed today.
- Define common risks that occur in small sized construction projects.

In order to reach these objectives, interviews have been conducted to collect data.

This paper presents the results of a pre-study forming a part of a research project which is investigating uncertainties in small sized construction projects. The research question to be answered in the pilot study is 'how to find out how risks and uncertainties are managed in small sized construction projects today'. Further research questions to be addressed in the research project are related to the relationship between theories, companies' policies and practical work, and also to the identification of obstacles and ambitions/incentives for uncertainty management in small sized construction projects.

1.3 Definitions

1.3.1 Small Sized Construction Projects

Searches of the literature did not provide conclusive evidence of what exactly characterises a small sized construction project, neither did discussions with different actors in the sector. The characteristics of a small sized project were subsequently discussed and agreed within the study's reference group. The result is sufficient description to distinguish these projects from very small projects, which are more in the nature of continuous business operations and, at the other end of the scale, from large projects.

The characteristics agreed upon of small sized projects for the purpose of this study are:

- contract value between 1-15 MSEK
- a site manager responsible for a maximum of two projects simultaneously
- limited construction time, maximum 12 months
- established technique, no development work
- project environment is independent
- personnel involved are more generalist than specialist

1.3.2 Risk and Uncertainty

In order to be able to discuss risks and uncertainties there needs to be some sort of definition of these concepts within the study. Uncertainty is part of everyday life, since we are not able to predict the future accurately. The amount of uncertainty and the ways in which we can handle this uncertainty could, however, be defined and structured.

According to Aven [7] uncertainty could be either aleatory or epistemic. An aleatory uncertainty is of a random nature and is hard to predict. An epistemic uncertainty is “lack of knowledge about fundamental phenomena”, which refers, for example, to the use of models and assumptions. In this study, uncertainty refers to both aleatory and epistemic uncertainty using Aven’s terminology.

Chapman and Ward [8] state that there is a need for a clearer focus on the upside effects, i.e. the opportunities. They also think that is desirable to let go of the historically close connection to events, conditions and sets of circumstances and instead shift attention to the different sources of uncertainty that could lead to threats of failure or, equally, opportunities. Their opinion is that it is vital to understand where and why uncertainty is important in a given project context and not to focus solely on threats and opportunities connected to given events, conditions or circumstances. Chapman and Ward [8] continue their line of argument with the suggestion that “uncertainty management” should replace traditional “risk management” to indicate that a wider perspective is being sought. This study starts with the aims of Chapman and Ward in order to widen the concept of risk management and use the concept of uncertainty management in its place.

The definitions of risk and uncertainty found in the literature are not consistent. There are several different definitions and approaches from different areas of research. According to the Project Management Institute [8] a definition of risk should take into account both positive and negative effects on a project objective. This is a broad view in terms of threats and opportunities and how they are connected to an event, a condition or a specific circumstance. Even if the risk according to [9] includes upside effects, the tradition is to focus on the downside, i.e. the negative effects. Project risk is defined as the “combination of the probability of an event and its consequences for project objectives” [10]. This definition is well known in the construction sector and elsewhere and is, by tradition, closely associated with a threat. Conversely, opportunity is neglected despite the enlightened definition found in [9].

It is necessary that each study defines its own approach and view of risk and uncertainty. In this study, the term uncertainty is used to point out the possibilities for both types: “risks”, with the negative effects; and “opportunities”, with positive effects. The definition of risk used here focuses on the negative outcome of an uncertainty and is seen as more dramatic than uncertainty.

Uncertainties are handled everyday on a construction project, but not all are of the type that needs special attention. In this study, uncertainty is defined as something that occurs and which was neither foreseen in the project description nor in the contract, being often caused by lack of knowledge on the part of one or more of the parties. The uncertainty could be an event that occurs during the project. It could also be something that is known from the beginning that makes the project unique, i.e., that makes it different from the standard procedure. Those uncertainties could lead either to risks or opportunities and need to be taken into account.

1.4 Research Limitations

Risks appear at different levels and likewise have different consequences for their surroundings. Depending on the approach taken, different risks will be found. In this study, risks in construction projects are examined, from the contractor’s perspective. Risks that appear at other levels are not considered, although they could affect the project’s objectives (figure 2).

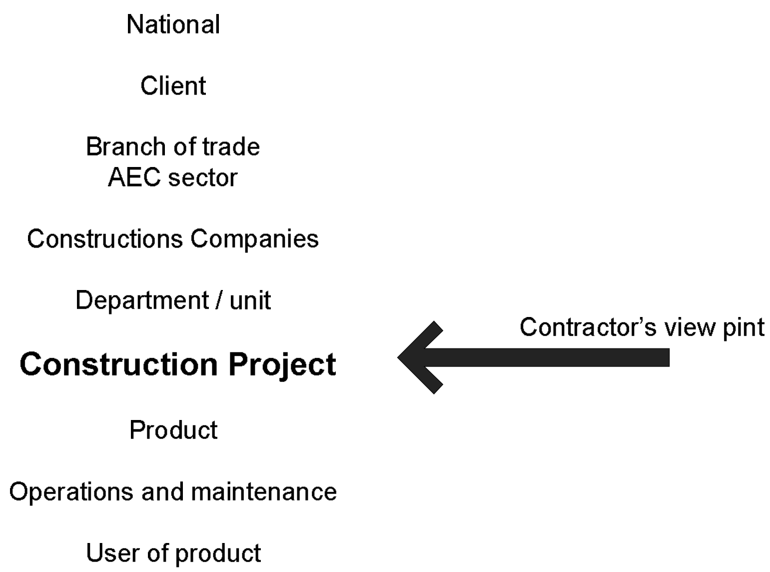

Figure 2. Selected approach for this project.

In the context of a construction project some further limitations regarding uncertainties and risks are considered in the study. Risk sources which are outside the framework of the study are, for example, political decisions, the financial situation of the client as well as the contractor, changes in organisation and illness among personnel involved in the project. These risks could have both positive as well as negative effects on the project's objectives, but are often out of the control of the site manager. For that reason, they will be left outside this study. Risk sources that are to be considered in this study are the project's economic boundaries, relationships with the client, technical solutions, aspects of production and weather. These risks are either within the control of the site manager or affect the project directly without interference from other levels of the company's organisation, for example, weather. Between these defined areas, risk sources from geotechnical engineering and the work environment will be found. These two areas represent many of the risks in the construction sector and have been studied separately earlier in other studies [3]. For this reason, they will not receive any special attention in this study.

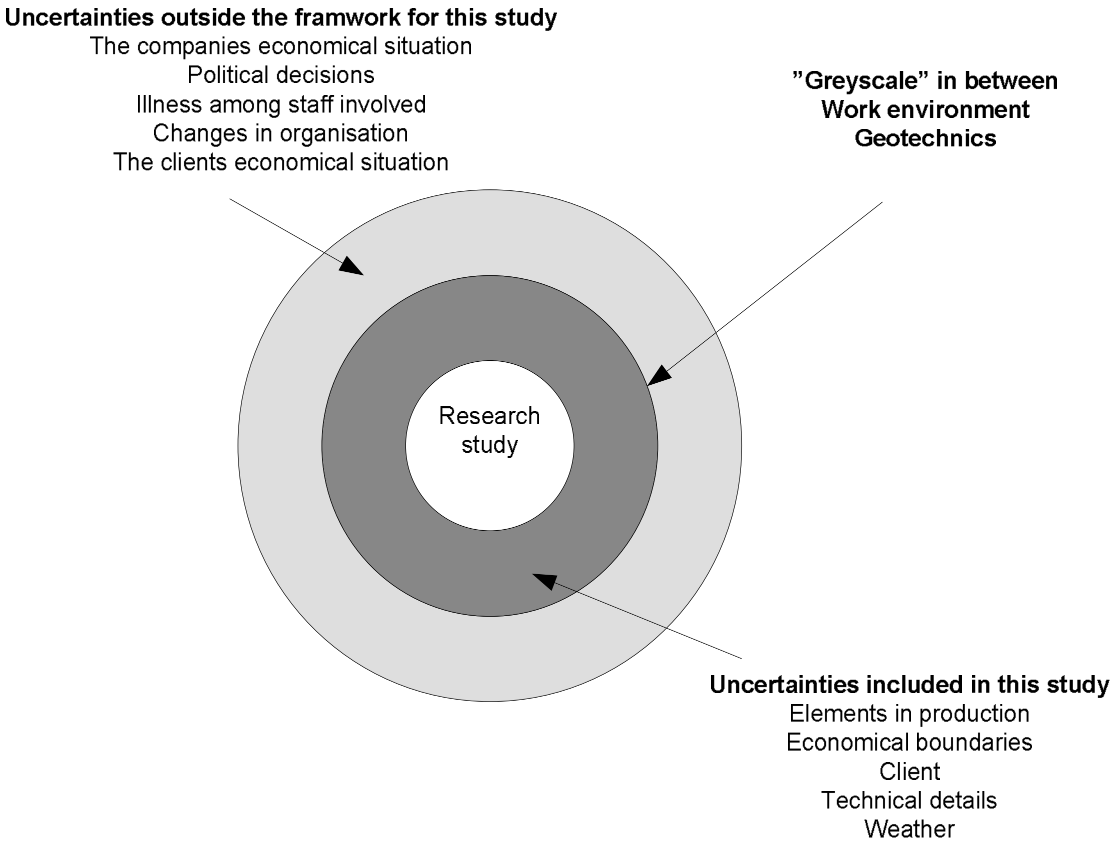

Figure 3. Risks and uncertainties in relation to the project.

2. Risk Management Today

2.1 Collection of Data

2.1.1 Method for Data Collection

The principal method used to collect data is interviews with managers of different projects from different companies. The strategy used for selecting projects is that the project must be either in a state of production or “fresh in memory”. Projects that have just started have not been selected because of the risk of the researcher affecting how risks are managed if the project is in the planning phase. There could be, as well, uncertainties in the answers if the projects were finished and the site manager had moved on to another project. Projects should also be selected according to criteria in the definition of small sized projects, not by who happens to be the site manager. Interviews with managers of projects from different construction companies have been adopted to provide a flavour of the wider construction sector.

In order to be able to see patterns in data from the interviews, the information has been sorted into different categories. Projects have been sorted by type: buildings, new production and renovation, and ground works. There is also some categorisation relating to the geographical situation, i.e. a medium sized community such as Luleå and a large city such as Stockholm, and the age of the site managers.

2.1.2 Interviews

Ten interviews have been undertaken with personnel from five different construction companies in Luleå and Stockholm, Sweden. The interviews were conducted in a semi-structured manner with a number of questions prepared in advance. The interviewees were free to speak about risks and opportunities in their projects and the researcher asked questions and gave some guidance to ensure that the prepared questions were covered. The interviews were conducted in a positive atmosphere and the interviewees have expressed an interest in seeing the final results of the study.

2.2 Findings

The findings from the interviews give a picture of what site managers in a few small sized construction projects think about risk management. They have shared both how they work with uncertainties, risks and opportunities and also indicated what they regard as the most common risks from their perspective. They have also given their view on what is defined as risk and uncertainty.

2.2.1 Perspectives on Risk Management

According to the site managers, risk is something that can have negative consequences for the project and is more dramatic than uncertainty. Conversely, uncertainty is regarded as something that can have positive as well as negative effects.

According to the site managers of the projects investigated, there exists a systematic framework for how risks and uncertainties are managed. There are manuals, routines and patterns to be used, not specifically for small sized construction projects, but specific to the actual type of project. For example, there are manuals for risk identification in ground works, general construction and buildings.

Managers of these small sized projects use the manuals and patterns to a certain extent, with some differences in application amongst them. They apply what they think is useful and leave the rest of the documentation alone. It is notable that there is a difference between the interviewees with respect to their age and experience. The older and more experienced managers tend to document less than others. This means that there are some who actually follow a systematic approach and others who work on intuition based on experience. Common for several of the managers is that they think continuous planning is the best way to manage uncertainties. "Risk analysis is quite good, but it is good planning and logistics that offer the best possibility for minimising uncertainties" (Andreas Rydberg, site manager NCC). In terms of planning, they are able to identify new uncertainties and to take precautions with respect to risks identified in the risk analysis. Risk analysis is performed for the tender and is part of the information the site manager gets before he takes on the project. The site managers refer to this risk analysis as a "living document" that should follow the project throughout the construction process. However, there are differences in how this is actually performed.

Risk analysis and "risk thinking" is not dependent on project size according the site managers interviewed. The approach to risk thinking is more dependent on the type of project than on the contract size of the project. It is the consequences of the risk that decides if the risk is qualified in the risk analysis and, in the first instance, the consequences for health and safety (Patrik Lamberg, Skanska). There are neither differences in available documentation nor in the extent of information in the documentation between large and small sized projects. This means that in very small projects the managers think that more time would be consumed to do documentation for the sake of the system than is actually required for production. The consequence of this is that the managers skip part of the documentation, if not most of it. There is also a time related aspect of these small sized projects expressed by this site manager: "In small projects it is vital that the personnel involved start off immediately since the time available is limited" (Leif Eklund, NCC). There are more possibilities to save a large project if a risk should appear, but the consequences of that risk if not saved might be large. The consequences of that same risk in the small project would be less, but might not be as easy to save due to tight schedule.

2.2.2 Identified Risks

In the small sized projects there are some risks that are more common than others. The relation to the client is one; lack of information in documents provided by the client is another. Yet another risk or actual uncertainty is the tender that establishes the boundary of the project. It is not possible to receive more money than the tender (i.e. contract) sum. The interviewees also think that there is a considerable difference in approach to risks and opportunities depending on what kind of contract is used. General contracts are considered safer in all respects. All aspects should be included and if something is missing it is the client's responsibility to solve the problem, not the contractor's responsibility.

For ground works projects the managers feel that there are a few risks. Small projects are rather straightforward, with known technology and known conditions in the project environment. The risks that appear are the same ones from time-to-time and there is limited uncertainty that crops up along the way.

In renovation projects, more uncertainties appear during production. The activities and technical solutions often need to be adjusted at the site level due to lack of information in the tender about the existing building. There are seldom standard solutions and whether something is a risk or an opportunity is much dependent upon the attitude of the client. Since there is a lot of uncertainty when doing renovation work it is hard to achieve a complete and reliable cost estimate for the tender. The tender (and, hence, the contract sum) does, however, define the financial boundaries for reaching the objectives of the project. This is also to be considered as an uncertainty.

One considerable uncertainty in new building projects is a tight schedule. Physical factors such as drying time for concrete are sometimes neglected, with the consequence that projects can end up with damp concrete. The risk of built-in faults could cause higher costs for both the contractor and client if not handled properly. Building projects also often include subcontractors and this involves uncertainties in relationships as well as in their attitudes to risk and uncertainty management.

Common risks for the small sized projects in this study are, without any ranking:

- contract documentation and tight schedules
- the client
- individual planning and logistics
- cost estimates in the tender
- subcontractors
- technical solutions
- safety for third parties
- weather

3. Conclusions and Further Research

The definition and characteristics for small sized projects are:

- contract value between 1-15 MSEK
- a site manager responsible for a maximum two projects simultaneously
- limited construction time, maximum 12 months
- established technique, no development work
- project environment is independent
- personnel involved are more generalist than specialist

Results from interviews show that there are common factors for small sized projects. These projects are managed both on intuition based on experience and systems for risk and uncertainty management. The systems are, however, developed with the intention of fitting all sizes of projects and are not specific to small sized projects. This leads to differences in the ways of applying risk management and is much dependent upon who is doing the risk analysis more than what the management system might advise. Site managers are also dependent on their own planning rather than having support from other personnel in the organisation.

Results from this pre-study have helped to sharpen the questions to be addressed in the next stage. The aim is also to give a picture of where risk management in small sized construction projects stands today. Knowledge about this situation makes it possible to continue with the remaining research questions:

- What are the differences between theories, companies guiding principles and the practical work in order to conduct uncertainty analyses?

- Why does uncertainty management work satisfactorily in some projects and not in others? What are the obstacles and ambitions of uncertainty management?

The plan for future work is to perform case studies during late 2005. In those case studies, further empirical results will be collected in order to arrive at an understanding for the performance of uncertainty management in small sized construction projects. The result of this future work will be a licentiate thesis to be finished by late 2006.

Acknowledgements

The author would like to thank the people involved in the research project's reference group for inputs and discussions in the research area. They have been of great help in the task of finding definitions and defining research boundaries. The reference group consists of people from different companies representing clients, contractors and consultants with practical as well as research experience. They have all reached advanced positions in their field and it is a major benefit for this study to have access to their experience and knowledge.

Thanks are also due to Valter Hultén of Sveriges Byggindustrier for his help with statistics on number of projects.

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Using a Construction Process for the Risk Identification

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Abstract

Every construction project can be divided into discrete phases each of which has its purpose, duration and scope of work. Risk management is a continuous process and should span to all phases through the project. A realisation of construction project is a process. A process is a group of activities undertaken with the goal of successful project realisation, and these activities are potential risk sources that may lead to an unsuccessful project. Risk management should be subordinated to the construction process.

This paper shows a new approach to risk identification in construction projects: process - driven risk identification. The Process Protocol developed at Salford University was chosen to show how construction process can be used for the identification of key risks. The Process Protocol is a plan of works and divides the construction process in ten phases from the Demonstrating the Need to Operation and Maintenance.

Keywords: Construction process, risk management, risk identification, Process Protocol

1. Introduction

Every construction project passes through phases, each of which has a purpose, duration and scope of work. Breaking the project down into phases is an important part of every construction process. The project must start from some kind of definition of need, after which follow design, contracting, construction and project completion [1]. Risk and uncertainty are inherent in all the phases through which the construction project passes, from Demonstrating the Need do Operation and Maintenance. Risks do not appear only in major projects. Although size may be a cause of risk, complexity, construction speed, site and many other factors that affect time, cost and quality to a greater or lesser degree cannot be overlooked. All the participants in the deciding process should observe risks and their effects on all key points of decision-making before and during project realisation.

Process in construction needs important changes and should be continuously improved. The process itself, and the changes and improvements made to it, are accompanied by risks whose adverse effects may increase planned costs and the time necessary for project completion, and decrease execution quality. Efficient and quality management of risks should make these changes in the construction industry possible and enhance quality and efficiency. Changes may be brought to the construction industry through improved risk management. One possibility is to study the causes of risks. In this case it is possible to muster the help of experts in that field, to identify the risks in all the phases of the project life cycle in great detail, to use a large database compiled from prior experiences on similar facilities, and to propose the most adequate risk response. This approach to improved risk management is partial solution with limited applicability.

A new aproach described in this paper starts from the fact that executing a construction project is a process and risk management should be adapted to this process. Risk management is a continuous process needing an integral risk management system in all the phases that the construction project passes through. It is necessary to identify the key risks that appear in all the phases through which the construction project passes, regardless of the type and size of the facility [2].

Risk management always starts with risk identification, which may be considered the most important phase of the risk management process [3]. Its purpose is to compile a list of risks important for a particular project. To form this list, it is first necessary to research the potential sources of risk, adverse events that include risk, and the unfavourable effects of an undesirable scenario. Risk identification greatly depends on the manager’s experience. If his/her experience with particular methods and techniques of risk identification is good he/she will continue to use them, whereas bad experience leads to avoiding approaches prepared earlier.

2. Process in Construction

A process is a series of activities (tasks, steps, events, operations) that takes an input, adds value to it, and produces an output (product, service, or information) for a customer. Customers are all those who receive that process output [4]. Construction developed as an industry when the approach to it changed and the process was introduced in building. In comparison with other industries, many special features burden process in construction and this makes changes leading to process improvement difficult. Structures are often very large and complex and it is necessary to organise construction processes on the building site according to space and time, while making optimum use of existing capacities. A production process of this kind is almost impossible to simply transfer among structures of different sizes and complexities. Production processes in construction last for a very long time, which increases the probability of detrimental events and the risk of running behind schedule. In its level of mechanisation construction still lags significantly behind other industries, and although machinery is increasingly replacing human work this is taking place much more slowly than elsewhere. Unlike industries predominated by production for an unknown client, structures are almost as a rule commissioned by a client or investor who stipulates the location, size, quality and purpose of the future product. Thus the investor should take part in the production process. Investors are usually inexperienced in this, which makes process development in construction additionally difficult.

According to Hughes [5] every project goes through similar phases in its evolution. The phases may vary in size and intensity, depending on the project. Hughes compared 7 plans of work published to date and concluded that many of them are more than a check list. Activities in construction projects to make up plans of work should be described in as much detail and in such a way that different projects may be compared. It is much more useful to concentrate on common aspects among projects than to begin analysis by describing the unique points of each project. He stated that the uniqueness is at a greater level of detail than the commonality, and therefore it should be modelled as such.

The division of the project into phases resulted from the desire to find a set of activities that should be carried out in the realisation of every construction project. This is the first step in establishing the construction process. Flanagan and Norman [6] divided the construction process in 4 phases. The RIBA Plan of Work [7] proposes 11 phases. The BPF Manual [8] proposes 5 phases. The Construction Industry Board [9] also divides the process in construction in 5 phases.

The Generic Design and Construction Process Protocol was developed as the result of a research project at the University of Salford by Professor R.Cooper and her team, in cooperation with several companies that were in various ways connected with the construction industry. The EPSRC (Engineering and Physical Sciences Research Council) under the IMI (Innovative Manufacturing Initiative) financed the project.

The Process Protocol [10] divides the construction process in 10 phases:

1. Demonstrating the Need
2. Conception of Need
3. Outline Feasibility
4. Substantive Feasibility Study & Outline Financial Authority
5. Outline Conceptual Design
6. Full Conceptual Design
7. Coordinated Design, Procurement & Full Financial Authority
8. Production Management
9. Construction
10. Operation and Maintenance

Lee, Cooper and Aouad [11] gave some advantages of the Process Protocol as an industry standard. It is these advantages that form the basis for an efficient framework for managing risk in construction projects:

1. *It takes a whole project view*. Process Protocol manages the project from recognition of the need for a building to its operation and maintenance and it is basically a generic process. Risk must also be managed through all the project phases independently of project type and size. Risk management must be placed in the function of the generic process, which means it is necessary to develop process-driven risk management.
2. *It recognises the interdependency of activities throughout the duration of projects*. Every activity that takes place within a project includes potentially risky events. Identification, analysis and response to these risks are the basis of every risk management framework. However, some activities are interdependent, overlapping or stretch through one or several phases of the project. This interdependence carries new risks which the framework must manage.
3. *It focuses on the front-end activities, paying attention to the identification, definition and evaluation of client requirements*. This makes it possible, at the end of each phase, to implement a new identification, analysis and find an appropriate response to the risks of the following phase.
4. *It provides the potential to establish consistency to reduce ambiguity, and it provides the adoption of a standard approach to performance measurement, evaluation and control to facilitate continuous improvement in construction*. Consistency, performance measurement and continuous improvement in construction are the foundation on which every risk management framework must develop.
5. *The stage-gate/phase-review process approach used facilitates concurrency and progressive fixity and/or approval of information throughout the process*. It illustrates the need for completing all necessary phase activities before proceeding to the next phase (hard gates) or allows concurrency (soft gates) without jeopardising the overall project success. Some types and/or sources of risk stretch through several project phases. Gates are the checkpoints where prior activities are reviewed and the decision made to start the next phase. The hard gate/soft gate philosophy may be directly applied to the risk acceptancy philosophy. Thus in risk terminology hard gate means that the risk is unacceptable and must be eliminated or transferred, and soft gate means that the risk is acceptable provided it is managed.
6. *It enables co-ordination of the participants and activities in construction projects and identifies the responsible parties*. Process Protocol groups project participants in Activity Zones according to their responsibilities. In Process Protocol risk is managed by introducing a new Activity Zone: risk management.
7. *It encourages the establishment of multi-functional teams including stakeholders. This fosters a team environment and encourages appropriate and timely communication and decision making*. One of the greatest risks in the early phases of the project is misunderstanding the client’s real demands. As an answer to this risk, Process Protocol anticipates the client’s active participation in all the project phases.
8. *It facilitates a legacy archive whereby all project information is collectively stored and can be used as a future learning vehicle*. The legacy archive is a very good place for

accommodating the Risk Register and database that may serve to identify, or analyse risk.

3. Identifying Risk in Construction Projects

As it unfolds the construction projects passes through several phases and in each of them it is possible to identify a large number of potential risks, i.e. events whose unfavourable outcome may be adverse for project success. Something could go wrong during practically any activity in project realisation. It would be very difficult to make a general list of all the risks for construction projects of any size or type, which would cover all the specific features of a particular project. A list of this kind would contain a certain number of high-exposure risks, but also a great number of risks whose exposure is such that they could practically be neglected. There would never be enough data for a quantitative analysis of a large number of risks, whereas a qualitative analysis of a large number of risks would be a time-consuming process subject to inconsistent assessments because of the great number of decisions that the risk manager would have to make to obtain their exposure and determine risk acceptability.

Reference sources provide a large number of attempts to compile a specific risk list in construction projects (Table 1). Most of these lists group risks in categories thus forming a hierarchical risk structure. The risk manager may analyse and compare the risk exposures of entire risk categories, he may select one or more key risks from a category and disregard all the others, or he may analyse risk acceptability for all the identified risks in a particular category.

Table 1 shows risk categories in construction projects according to several authors [12,13,14,15,16]. The risk categories in other industries are similar. These risks may appear and be analysed in all construction projects regardless of size or type. Although similar risks often appear under different names, the table shows the great diversity in identifying risk categories among different authors. The five risk lists in the table contain as many as 31 risk categories.

Risk identification with the help of previously existing risk lists is completely adapted to risk-driven project management and does not take into account that executing a construction project is a process and that risk management must be subordinated to that process.

Table 1: Risk lists

	RISK	CARTER at al. (1994)	GODFREY (1996)	SMITH (1999)	DEY (2001)	RAMP (2002)
1	Political		x	x	x	x
2	Environmental		x	x		
3	Planning		x			
4	Market	x	x			
5	Economic		x		x	x
6	Financial	x	x	x	x	x
7	Natural/Act of God		x		x	x
8	Project		x			x
9	Technical		x		x	
10	Human		x			
11	Criminal		x			
12	Safety		x			
13	Strategic	x				
14	Contractual	x				
15	Master Plan	x				
16	Definition	x				
17	Process	x				
18	Product	x		x		
19	Organisational	x			x	
20	Operational	x				
21	Maintenance	x				
22	External	x				
23	Legal			x		
24	Social			x		
25	Communications			x		
26	Geographical			x		
27	Geotechnical			x		
28	Construction			x		
29	Technological			x		
30	Statutory clearance risk					x
31	Business					x

4. Risk Identification Based on Process Protocol

The risk management process, and thus also risk identification, which is part of it, have to be subordinated to the construction process. A process is a group of activities undertaken with the goal of successful project realisation, and these activities are potential risk sources that may lead to an unsuccessful project. The construction process consists of phases through which the project passes. Regardless of the project characteristics, the key risks of the construction project are the risks that may prevent the goals of a particular phase in the process from being achieved.

The goals of each phase depend on several activities or processes that affect phase realisation in various ways. Not achieving the goals of one or more of these processes may lead to non-achievement of the goals of the phase they belong to. Depending on their complexity, some processes contain sub-processes that may be broken down even further.

Independently of level, the processes in a particular phase that have the greatest probability and the greatest impact on the time, cost and quality, and thus also the greatest bearing on successfully achieving the goals of that phase, are the optimum choice as sources of key risks that are not project related. This means that the key risks on which the success of the process depends can be reached by analysing the construction process. In this way risk management is placed in the service of the construction process, and leads to process improvement.

Process Protocol II, developed by R.Cooper at Salford University in cooperation with Loughborough University, resulted in breaking down high level processes (Level I) into sub-processes (Level II and Level III) in each phase through which, according to Process Protocol, the construction project passes from Demonstrating the Need to Operation and Maintenance [17]. Process maps were made for each level. These process maps show the advantage of Process Protocol over other plans of work because they provide better insight into the elements of the process and thus also into risk identification. Figure 1 shows an example of dividing a process into sub-processes according to Process Protocol II. For Phase Zero, *Demonstrating the Need*, it shows the division of the high-level process *Establish the Need for a Project* (Level I) into sub-processes (Level II and Level III).

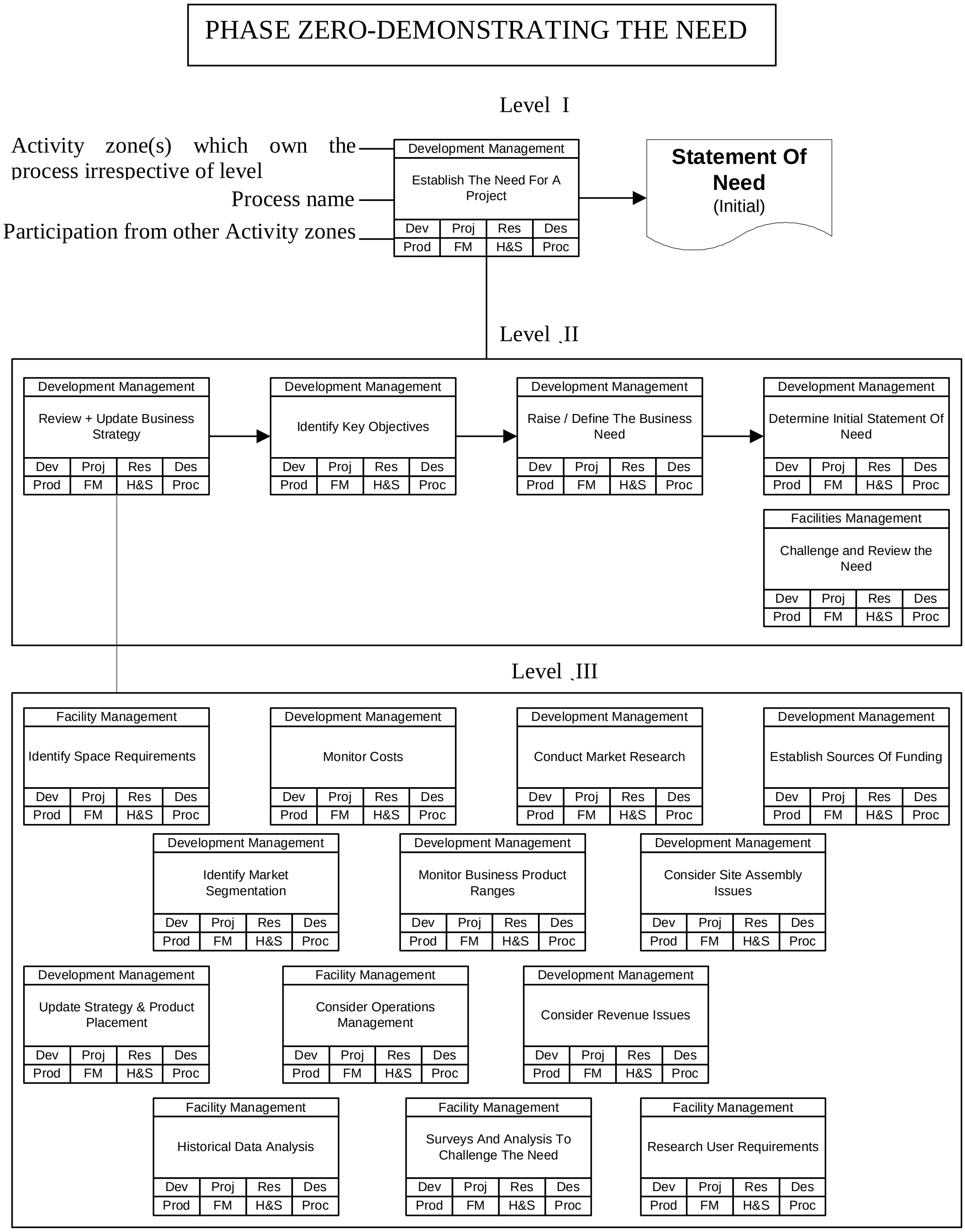

Figure 1: Development of sub-processes

Abbreviations: Dev - Development Management, Proj - Project Management, Res - Resource Management, Des - Design Management, Prod - Production Management, FM - Facility Management, H&S - Health and Safety Management, Proc - Process Management

The author of this paper compiles the proposed list of key risks for Phase Zero, *Demonstrating the Need* to show how construction process and sub-processes can be used for risk identification:

Risk 0-1: Unsatisfactory Market Research

In this earliest project phase it is necessary to research the market of existing structures which may help the client express his requirements or demands as clearly as possible. This is especially important as some of the stakeholders will be participating in the realisation of such a project for the first and only time. When they see what they could obtain, clients will be able to express what they really want much more clearly. Without market research and the presentation of the research results to clients there is a significant risk that the goals of phase zero will not be fulfilled.

Risk 0-2: Ill-defined Initial Statement of Need

All the client's needs, goals and demands should be described in as much detail as possible in a document according to Process Protocol called Statement of Need. In this early project phase it is very difficult to define all the demands and needs. In further project phases the elaboration and evaluation of potential solutions will lead to their reduction or may even extend the demands of the client, i.e. the stakeholder.

Risk 0-3: Incomplete Stakeholder List

Each stakeholder has his needs and demands, depending on his investment in the project. An incomplete stakeholder list makes it impossible to form all sources of funding and means that demands differing from earlier ones may appear. An incomplete stakeholder list is a risk for the entire phase zero not fulfilling its basic goals.

Risk 0-4: No Historical Data Analysis

In the earliest project phase, after the client's needs, goals and demands have been defined, it is necessary to analyse available data about all risk sources on similar projects that have already been executed. There is also a risk of leaving out of the risk list a risk that in the past showed significant risk exposure in a project phase. Analysing available data considerably contributes to a better understanding of the problem.

Risk 0-5: Poor Communication

In the earliest project phase it is necessary to establish a communication strategy within the management team participating in the project phase (development, resources, facilities, project and process management) and between the management team and the client and stakeholders. Success in realising the goals of phase zero greatly depends on this communication.

5. Conclusions

Risk management is by nature a cyclical process. Risks must be identified before the beginning of project realisation or the realisation of any phase through which the project passes. The environment in which the project is realised produces new risks during project realisation. The new risks must be analysed together with those identified and analysed earlier, in a continuous attempt to assess the probability and adverse effect of new risks in relation to existing ones. This creates the need for continuous risk management in all phases of project realisation.

The execution of a construction project is a process. The process in construction contains many special features in comparison with the process of other industries, which are an impediment for changes leading to process improvement. The risk that the project might be unsuccessful is in fact the risk that particular elements in the construction process might be unsuccessful. Risk management should be subordinated to the construction process. Improving certain elements of risk management lead to better understanding and to changes, in other words, to improvement of the construction process, which is one of the main goals of the construction industry.

The Construction Process Protocol is by nature a generic process and is thus suitable for the construction process within which risk management will be situated. As a plan of work, Process Protocol enables managing the project from Demonstrating the Need to Operation and Maintenance regardless of the type, size and purpose of the project that is being realised. According to Process Protocol, every project can be executed through the successful execution of 10 phases. Every phase contains so-called high-level processes as a group of activities that must be realised for the successful conclusion of that phase. High-level processes are broken down into sub-processes in as many levels as the Protocol user deems necessary for the project. The break down of the process in sub-processes provides a good foundation for identifying key risks that are independent of the project being realised. Sub-processes are potential risk sources so risk management in fact means ensuring the success of each sub-process within the entire construction process. Ensuring the successful execution of the construction process leads to process improvement, which gives additional weight to Process Protocol.

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Breakeven Analysis for Selecting Construction Methods: Precast vs. Cast in Place Concrete

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Abstract

In Saudi Arabia, it is common practice that most of the structures of individual housing and small building is erected by Cast in Place (CIP) concrete while most of the structures of mass houses and large building and malls are one of Precast concrete (PC). The reason for the previous characterization is dictated by the economics, shortening of construction period, knowledge of the contractor, and aesthetics. Gradually but slowly, PC is taking more territory for the traditional CIP. The aim of this paper is to devise criteria for selecting either of the above methods from an economic perspective. The criteria will help the owner/contractor/designer to decide the favor ability of either construction method based on the size of the project.

Keywords: Precast Concrete, cast in place concrete, and construction method, Saudi Arabia

1. Background

Many structural systems have been used in the housing and building industry of Saudi Arabia which is predominated by the two systems, Cast-in-Place concrete structures, short named CIP; and that is of Precast concrete structure, short named PC. This practice has been dictated by cost competitiveness, contractors experience, aesthetics, flexibility and lower cost of change orders and other factors. It is common to have individual family detached dwellings of two stories built with CIP concrete because it is more economical and flexible whereas mass housing and large commercial and office buildings are built with PC concrete for their modular design, repetition of standard structural members, and economics of scale.

The choice between the two structural systems by owners/designers/contractors, based on their areas or space volumes and thus costs, are comparable in some cases of construction projects.

2. Problem Formulation

Designers and Engineers are frequently requested by the owners to advise them more accurately on the most economical structural system when their estimates are based on previous projects, quotations and rules of thumb. Hence, in the case of evaluating a CIP concrete structure versus PC concrete structure for a given project, a quantitative method of comparing the two alternatives in terms of their construction costs, is desirable in the early stages of architectural and structural design. The total costs for the contractor in a construction projects equal to the total direct costs and total indirect costs. For simplicity, this relation can be expressed as cost function as follows [1]:

$$\sum RC\_Cost = \sum DC \times Qi + \sum IC \times Ti \qquad \textbf{Eq.1}$$

Whereas the following symbols represent the stated variables:

RC_Cost (in SR):	Total concrete cost in Saudi Riyals for either CIP or PC.
DC (in SR/Cu Meter):	Direct costs of proportional erected concrete (i.e. dependant on the quantity of erected CIP or PC concrete).
***Qi (in Cu Meter)*:**	Quantity of concrete in cubic meter for either CIP or PC.
IC (in SR/day):	Indirect costs for concrete works that is proportional to the duration of concrete erection.
Ti (in Days):	Duration of Concrete Erection (including Manufacturing for PC Concrete)

The relationship between the cumulative cost of concrete works (including pouring/erection) and quantity of concrete measured in cubic meters can be simply expressed by the following equations.

3. Example Project Real Data

To examine the formula for selecting either of the two structural systems of CIP or PC, relevant input data is drawn from two compatible projects utilizing both structures. Table 1. presents unit prices and quantities of concrete for major structural members for CIP and PC systems, which are drawn from two colleges building projects in King Saud University located at Riyadh, Saudi Arabia [2], [3]. The two projects have similar project definitions and are presumably equivalent in price, size and quality. The CIP concrete activity duration, per schedule of the contractor when reviewed by the author, is 320 days while the PC concrete activity duration (design and manufacturing and erection) is 240 days.

Table 1: Quantities of Concrete Works by Structural Members [2], [3]

	College of Architecture and Planning Project			College of Computer Science Project		
Type of Structure	**Cast-In-Place Concrete**			**Precast Concrete**		
Structural Member	**Quantity of Concrete (In Cu Meter)**	**Unit Cost (In SR/Cu Meter)**	**Total Cost for Individual Structural Element (In SR)***	**Quantity of Concrete (In Cu Meter)**	**Unit Cost (In SR/Cu Meter)**	**Total Cost for Individual Structural Element (In SR)**
Foundations	2675	700	1872500	2174**	650	1413100
Columns	772	800	617600	564	1520	857280
Beams	4702	800	3761600	4100	1700	6970000
Slabs	6295	800	5036000	2678***	700	2574600
Stairs	161	900	144900	161	2800	450800
	Cumulative Costs		11432600	Cumulative Costs		9691180

* SR, Saudi Riyal, is Saudi Arabia currency which is equivalent to US $ 0.27
*CIP Concrete is used for foundations and slab on earth for PC structure
** Volume of the PC slab is much smaller than the CIP slab since it is a hollow slab with 0.3 meter of thickness

4. Formula Derivation

4.1 Cast-in-Place Concrete (CIP) Structure Costs

From Table 1., total Quantity of CIP concrete is 11,769 cubic meter is to be erected in 320 days (from project schedule) at average price of 800 SR/M³ for all structural members excluding foundation and stairs (which are common for both alternatives); therefore

Total cost = 11769 * 800 = 9,415,200 SR.
Assuming an inverse linear relationship between concrete cost and duration of its erection and that all concrete works fall on the critical path, then

Cost of 1000 m³ CIP concrete = 8,000,000 SR Eq 2.
And if the Time for erecting 11769 m³ of concrete is 320 days; then
Time to finish 10,000 m³ of concrete is 272 days.

Assuming indirect cost & profit margin is 25% (of 8 millions) of total costs which is 2,000,000 SR; and then
The indirect cost & profit margin / day = 2,000,000 /272 = 7353 SR /Day Eq. 3
Thus, the direct cost for 10,000 M3 of CIP concrete is 6,000,000 SR, i.e.
Direct Cost = 600 SR/ m³ Eq. 4

For simplification, the findings of equations 2-4 are represented by the following variables:

DC1: Direct cost = 600 SR/m³
T1: Time for finish 10,000 m³ = 272 days
IC1: Indirect cost & profit margin = 7353 SR

Substituting the above variables in Eq.1, then it can be written as follows:
Total Costs (in SR) of CIP concrete = DC1*Qi + IC1*Ti
= 600 * Qi + 7353*272
= 2000016 + 600 * Qi Eq. 5

4.2 Precast concrete (PC) Structure Costs

From Table 1., total Quantity of PC concrete is 12699 cubic meter is to be erected in 240 days (from project schedule) at average price of 1060 SR/M³ for all structural members excluding the foundations and stairs; therefore,
Total cost of PC concrete = 12699 * 1060 = 13,460,940 SR.
And by extrapolation between concrete cost and duration of its erection given all concrete works fall on the critical path, then

Cost of 10,000 m³ PC concrete = 10,600,000 SR Eq 21.
And if the Time for erecting 12699 m³ of concrete is 240 days; then
Time to finish 10,000 m³ of concrete is 189 days.

For the sake of simplicity, assume that the indirect cost & profit margin for the PC contractor is similar to contractor of the CIP, then
IC2 = IC1 = 7353 SR/Day Eq. 31
Total Indirect Cost for PC concrete = 7353 SR/Day * 189 Days
= 1,398,717 SR

Thus, the direct cost for 10000 M^3 of PC concrete = 10,600,000 SR – 1,389,717 SR
= 9,210,283 SR, or
= 921 SR/ M^3 Eq. 41

For simplification, the findings of equations 21,31 and 41are represented by the following variables:

DC2: Direct cost = 921 SR/m³
T2: Time for erecting 10,000 m³ of PC concrete = 272 days
IC2: indirect cost & profit margin = 7353 SR

Substituting the above variables in Eq.1, then it can be written as follows:
Total Costs (in SR) of CIP concrete = DC2*Qi + IC2*Ti
= 921 * Qi + 7353*189

$$= 1389717 + 921 * Qi \qquad \text{Eq. 51}$$

4.3 Finding the Breakeven Point

Having developed Eq. 5 and Eq.51 for the relationship between both CIP and PC quantity of concrete versus total costs of erection, then a breakeven point whereby both linear equations are equal in total costs and equal in quantity of concrete can be found by equating Eq. 5 and Eq.51 as follows:

TC1 = TC2, i.e., 2000016 + 600 * Qi = 1389717 + 921 * Qi, and thus

Qi = (2000016 - 1389717) / (921 – 600) = 1901.24 Cubic Meter of concrete.

Table 2. Presents the values of CIP concrete and PC concrete costs in SR/Cu Meter for ascending quantities of concrete in Cu Meter. When the two previous variables plotted in X-Y plane as in figure 1, which it shows the breakeven occurs at Qi = 1901.24 Cubic Meter at a total cost of 3,200,016 SR. From the figure, we can see if the total quantity of the used concrete is less than 1901 cubic meter then it is cheaper and favorable to use the PC concrete while if the required quantity of concrete is more than 1901 cubic meter, then it is cheaper and favorable to use CIP concrete for the structure of the building.

Table 2 : Data of the Concrete Quantities vs. CIP/PC Costs

Data No.	Quantity of Concrete (Cu Meter)	Cost of CIP Concrete (SR/Cu Meter)	Cost of PC Concrete (SR/Cu Meter)
1	500	2300016	1850217
2	1000	2600016	2310717
3	1500	2900016	2771217
4	2000	3200016	3231717
5	2500	3500016	3692217
6	3000	3800016	4152717
7	3500	4100016	4613217
8	4000	4400016	5073717

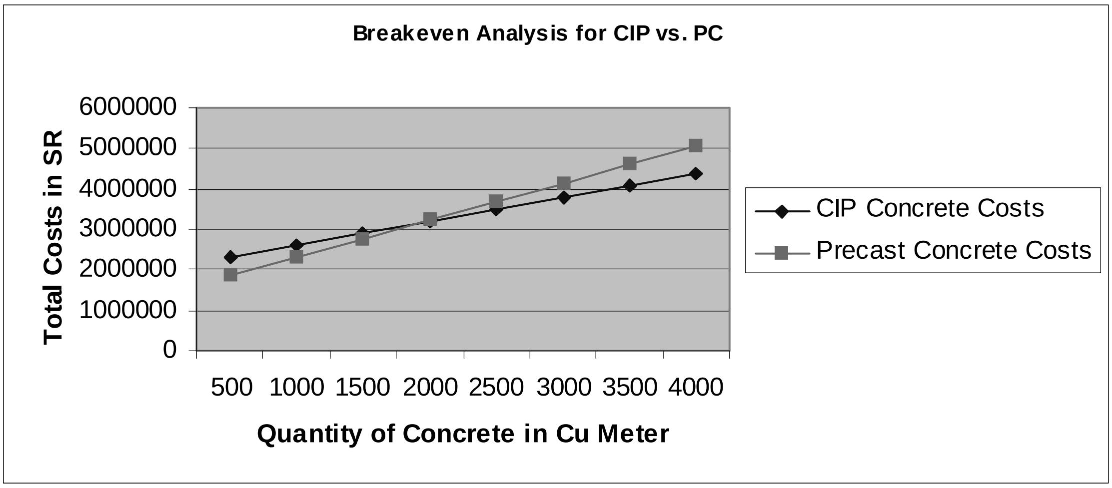

Figure 1: Plot of Concrete Quantities vs. CIP/PC Costs

5. Conclusions

Breakeven formula is derived to preliminarily evaluating and selecting best alternative between two competing construction methods offered by two different contractors for the structural members, those of Cast-in-Place concrete vis-à-vis Precast concrete. The criterion for selection is based on the most economic solution. The quantities of works, i.e., concrete, are treated as independent variable while the component of contractor overhead is held constant and equal for both contractors. The outcome of this research assist decision makers and engineers to compare both concrete construction methods early in the construction planning phase of a project. The approach developed herein can be also applied for similar construction methods for other project activities.

The author intends to further treat the validations of the findings in upcoming paper.

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Systemic Innovation in the Management of Construction Projects and Processes

In an industry that is dominated by one-of-a-kind projects, and a thin profit margin, a key challenge in the new global economy is to ensure delivery of projects that are on time, within the cost limits, of high levels of quality, sustainable, and provide value to the customer. All this, while ensuring that contractors remain profitable without raising project costs. This calls for systemic innovation in the management of construction projects and processes that takes into consideration all relevant aspects and stakeholders of the complete building lifecycle.

The challenge of systemic innovation in the management of construction projects and processes has been taken up in this book. Contributions and experiences from Australia, Brazil, China, Croatia, Finland, Norway, Saudi Arabia, Sweden, Taiwan, The Netherlands, United Kingdom, and USA unveil how systemic innovation is being used to manage projects, product processes and control, productivity and performance improvement, product delivery systems and contractual practices, and risk management.

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SECTION II: Emerging new FM aspects

SECTION III: Needs and expectations of customer

SECTION IV: Workplace management

SECTION V: Sustainability in facilities management

SECTION VI: Innovation and development in facilities management

Preface

This book highlights facilities management and its business experiences from four continents as they were presented in an international CIB 2005 Helsinki Symposium. The book containing 57 papers is divided in six chapters each describing highly interesting topics of built facilities and their management.

The changes and recent developments in facility management industry have been very efficient: new knowledge and solutions are widely used and business is coming more and more globalise. Those who can successfully interpret changes happening in the construction and facilities businesses can achieve significant gains. Business environments are constantly changing thereby providing new opportunities for innovative firms.

Emerging solutions for defining end products, relying heavily on the preferences of users to guide all services are clearly providing a mind shift from supply-driven to end-user-driven attitude. The needs and expectations of customers and end users are highly ranged.

Today's businesses and working life demand highly usable workspaces and flexible spaces and buildings and also versatile new facility management services. Present needs cannot be extrapolated over decades. Active, innovative research and development work is needed all the time.

Also facility management needs sustainability. Sustainable concepts, sustainable buildings and infrastructure are affecting facility industry and business, its management and the underlying knowledge, methods and solutions.

Also new concepts, methods and solutions for explaining built environment quality, safety and functionality are covered by this book.

We hope this book finds interest among practitioners and researchers willing to implement and develop further the facility management as an independent service industry and business area.

Kauko Tulla

VTT - Technical Research Centre of Finland

Helsinki, June 2005

Section I

Facilities management business

Development of Strategic Stock Management System for Public Building Facilities

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Abstract

In Japan, long use of social capital stock is now our crucial task in terms of both fiscal issues and global environmental problems. "Strategic Stock Management Method" that we developed is a group management method of social capital stock, and in the sphere of building, it consists of, a) simplified evaluation method, b) combination of various types of building life prolongation technologies, and c) impact analysis of management schemes to various social and environmental aspects. This paper examines the problems for stock management that confront us and presents our concept of "Strategic Stock Management", and taking public buildings of a city as objects of case study, show its effectiveness to our problems.

Keywords: Public Building Facilities, Group Management of Facilities, Stock Management, Asset Management, Simplified Evaluation Method

1. Building and Infrastructure Stock Management in Japan

In spite of scrapping and building of massive buildings and infrastructures Japan has undergone during the rapid economic growth and social transitions, long use of housings and social capitals are now our crucial task in terms of both fiscal issues and global environmental problems (Figure 2 - 5).

Owing to the rapid development of Japanese economy and accumulation of construction activities, massive stock of buildings and infrastructures has been formed, but the progress of time and the development of living environment have invited the rapid obsolescence of its function in the both terms of soft and hard. As for publicly managed housing and social capital under the present severe financial conditions of public investment reductions, the maintenance and the replacement cost for the voluminous stock is estimated to leap in the near future, and new building and construction investments will be even harder.

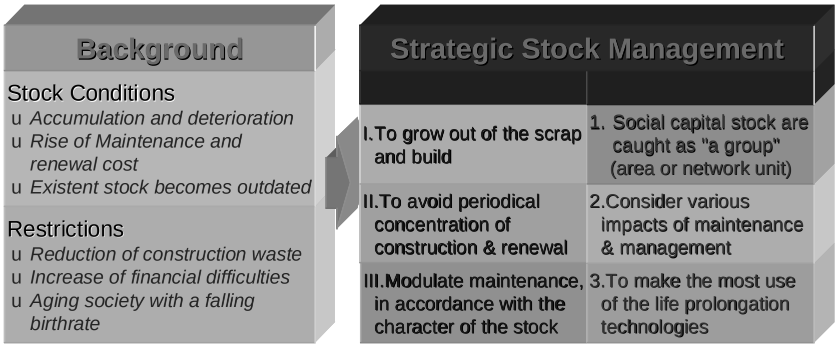

Figure 0: Backgrounds and Conditions of Strategic Stock Management

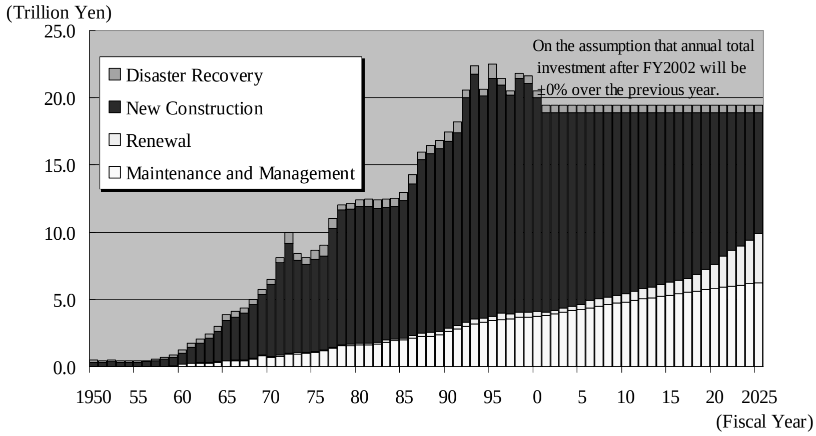

Figure 0: Estimates for Investment of Social Capital Stock in Japan (by MLIT 2002)

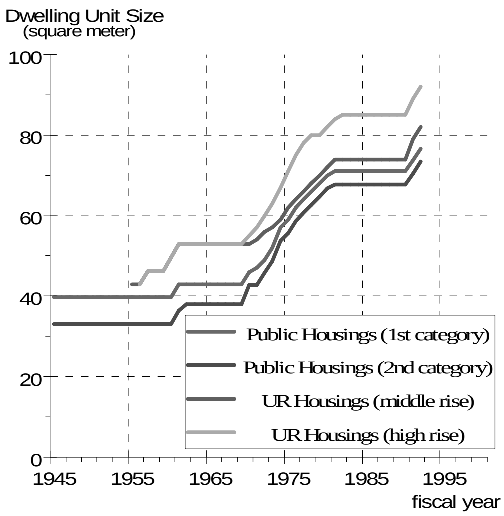

Figure 3: Outdating of Existing Stocks

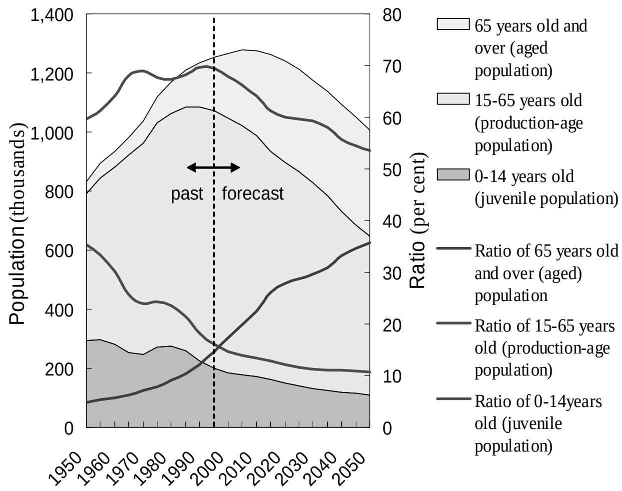

Figure 4: Change of Social Conditions (Population)

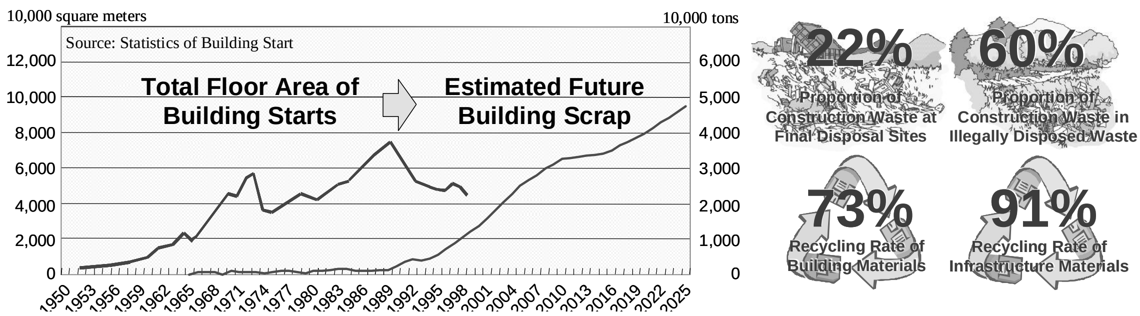

Figure 5: Necessity to Control Production of Building Waste

On the other hand, with the issue of global warming focused on, the decrease of waste and global warming gasses from building and construction activities is demanded.

What we must do, along with developing and making use of technologies to extend the service life of individual buildings and infrastructures is to develop technologies to control the life span of all social capital to adjust the peak demand for renewal. It is for this context that our institute is conducting studies into the 'Development of Asset Management Technology for Housing and Social Capital' (2001-2004), with the objective of developing a "Strategic Stock Management" method that will enable us to maintain, manage, operate and renew multiple facets of our social capital in a planned, strategic manner (Figure 1).

2. The Concept of Strategic Stock Management

The concept of "Strategic Stock Management" at our start point can be described as following.

If we are to make more effective use of housing and social capital, it is vital to have a grasp of the conditions of each facility and manage each appropriately. To allow selection of the most appropriate for maintenance and management depending on facility conditions and functions, evaluation of the characteristics and effectiveness of separate technologies are required. According to the diagnosis of the degree of facility deterioration, we can extend facility service life that will ensure the required functions for the necessary periods through repair and reinforcement, or extend service life by converting use of the facility.

As we evaluate the effects of these technologies, it will make possible to formulate and evaluate maintenance and management plans for each separate facility -- plans with comprehensive perspectives including environmental impact, costs, and user convenience. Specifically, we compare the different plans in comprehensive ratings that consider cost and environmental impacts in order to choose the best plan. Here is an example of how selection would be made from among plans A, B, C, and D (Figure 6). Plan A calls for maintenance of the facility in a way that makes it possible to maintain its performance consistent with its original purposes until it reaches the end of its life span. Plan B call for maintenance to be carried out at lower levels than are required by Plan A, but schedules major scale repair work at some future point. Plan C would convert use of the facility before the end of its designed life span and would maintain the facility in a way to support its expected performance until the target date. Plan D would retain the facility even after the end of its designed life span by converting facility use in a manner different from Plan C.

However, formulating the best maintenance and management options for individual facilities is not sufficient to formulate appropriate plans for maintenance, management, and renewal that cover the overall inventory of the stock. To that end, we have to, in a certain management unit, overlook the whole facilities, estimate the change of necessity and coordinate maintenance and management plans of each facilities so as to maximize the function, minimize the environmental load, average financial expenditure of the facility as a group (Figure 7).

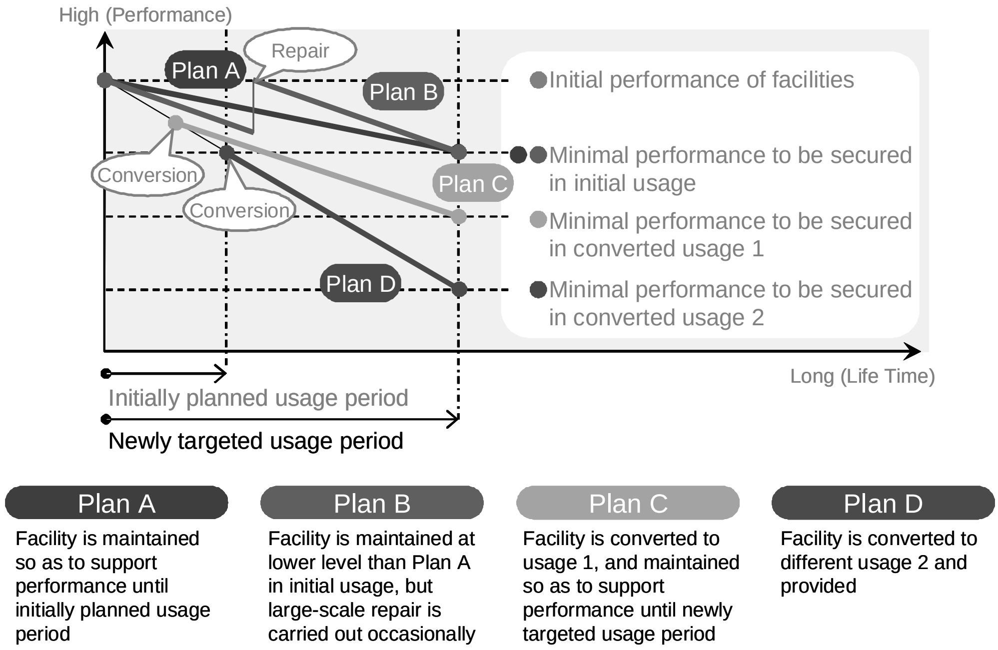

Figure 6: Planning of an Optimum Management Plan during the Usage Period

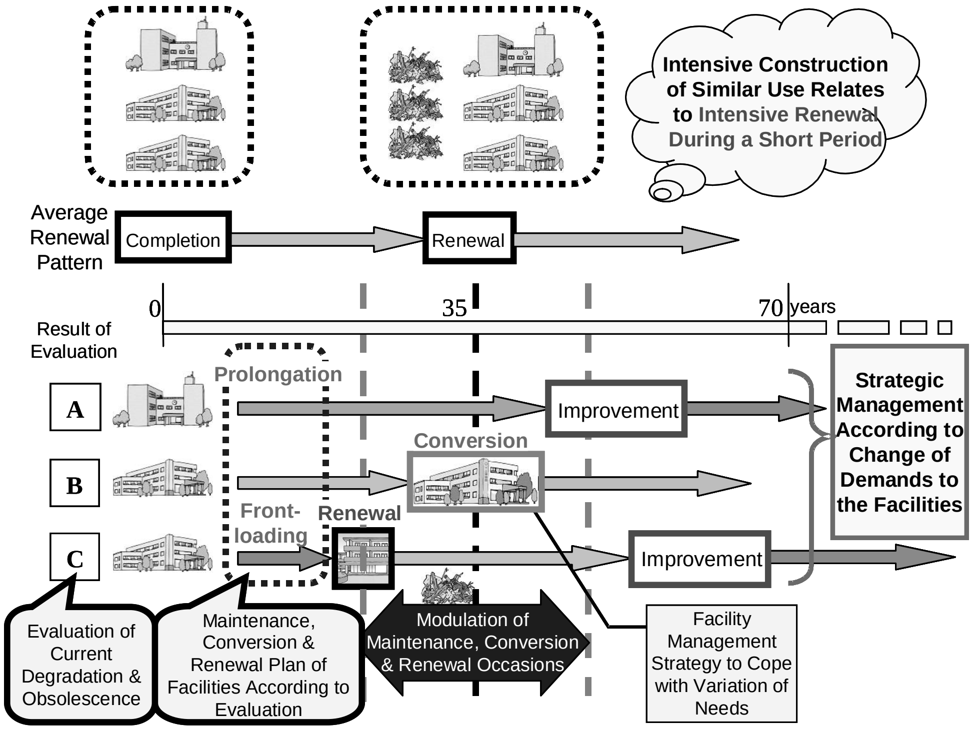

Figure 7: Approach to Group Management of Facilities in Strategic Stock Management

In brief, what we tried to achieve through the development of an overall strategic stock management system is to establish the comprehensive technology to manage and operate more than one facet of housing and social capital, i.e., ‘stock’, in a certain area by making the best use of technologies to extend life spans, repair, enhance functions or convert facility use with consideration for social aspects such as financial conditions, asset value, the impacts on global environment, effects on communities, historical value, and perhaps, preservation of scenic beauty.

3. Developing Evaluation Methods of a Building

The actual research and technology development were executed targeting public buildings of small and medium size local governments (municipalities). Through questionnaires the characteristics of building stocks and their management in these bodies has been identified as the followings.

- They have many building stocks, which are comparatively old, and of various use. The local government owns 780 thousand buildings and 500 buildings in average, while the national government owns 150 thousand buildings. Schools and public housings account for 2/3 of the buildings, and in total, their variety of use is 28 categories. Approximately 60% of the buildings are more than 20years old, and 55% are built before the new earthquake-resistant design method came in to effect (1981).
- The facilities are managed by each department in charge, and not by a single facility managing department who manage the whole stock. Building engineers occupies only 1.5% of the whole employee, and engineers play only a small part in facility management. Data accumulation for management is insufficient and there isn't a common form of facilities register in most municipalities let alone taking of maintenance and repair record.
- Despite inspections of building elements and equipments take place, diagnosis and examination of a whole building is rare. Only corrective maintenance is done only coping to troubles after they become obvious and preventive maintenance or long-term repair program rarely takes place. Because of financial difficulty, seismic rehabilitation remains undone.

Thus the situation in these municipalities are that, despite the amount, variety, deterioration and outdating of their building stocks, they do not have a comprehensive plan to cope with, lack accumulation of inspection data to support the necessary decisions, and are short of persons of talent who make the steps forward.

To solve these problems, we have developed an evaluation system of the buildings that are simple; not time and money consumptive, understandable, and can be carried out by in-house non-expert. To do this we have prepared filling sheets, by checking the items of which, a rough evaluation is executed. There are three types of evaluation and there are filling sheets for each type.

The first is for understanding and evaluating the present condition and function of the building. By checking the 32 sub-items they will be summarized to 15 main items or 5 categories of performance level as of Table 1, and the elements and the details which need repair and improvement is clarified.

Table 1: Performance Evaluation Categories and Items of Existing Buildings

Category	Main Item	Subitem (Performance or Alternative Characteristics)
I. Safety	1. Safety of Building Frame	1-1. Completion year of the building
		1-2. Execution of seismic strengthening and structural resistance
		1-3. Deterioration of the building frame
	2. Safety of External Facing	2-1. Waterproofing of the roof
		2-2. Leak from the external facing
		2-3. Deterioration of exterior materials
	3. Disaster Prevention Safety	3-1. Indication items by fire inspection
		3-2. Evacuation safety
		3-3. Problems of fire protection and crime prevention equipments
II. Function	4. Spatial Extent	4-1. Story and ceiling height
		4-2. Size of the rooms and convenience
		4-3. Deterioration of interior materials
	5. Indoor Environment and Faciity Functio	5-1. Performance of air conditioning, sanitation, sound, and light
		5-2. Performance of equipment machines and convenience
		5-3. Equipment capacity and crime prevention performance
	6. Barrier Free	6-1. Response of the building
		6-2. Response of the equipment
	7. Information Capability	7-1. Wiring space (OA floors)
		7-2. Reliance of information equipments against disasters and crime
III. Environmen	8. Decrease of Environmental Load	8-1. Energy and resource conservation response
		8-2. Longevity response
	9. Environmental Conservation	9-1. Consideration for the surrounding
		9-2. Ecomaterial, waste removal
IV. Sociality	10. Landscape	10-1. Contribution to landscape
	11. Locality	11-1. Consideration for local history, culture and climate
	12. Capacity	12-1. Floor area per user
	13. Utility	13-1. Utilization factor
		13-2. User satisfaction level
V. Economy	14. Maintenance Costs	14-1. Annual cost (electricity, gas and water supply)
		14-2. Operational cost prospect (per life-cycle)
	15. Asset Value	15-1. Residue value
		15-2. Service level of the facility

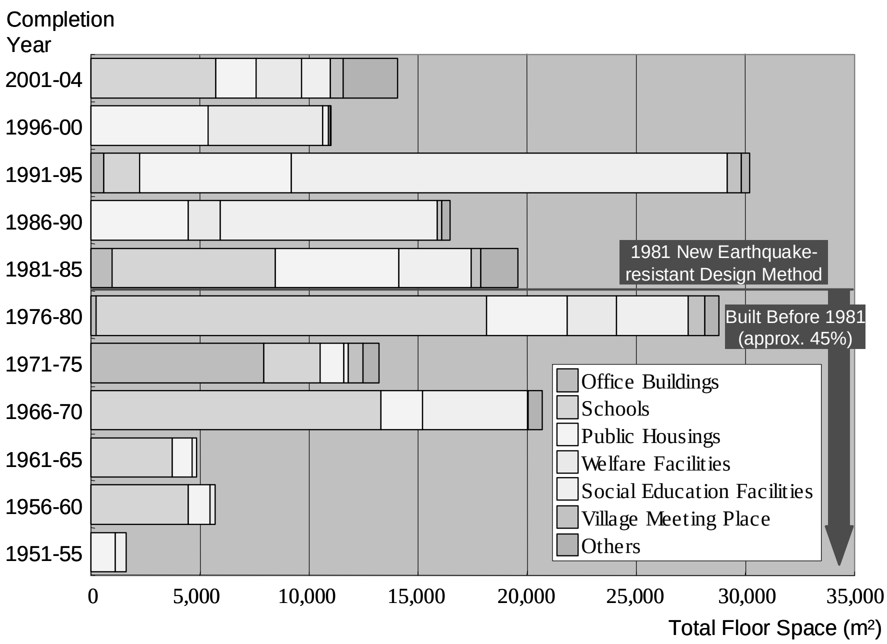

Figure 8: Building Stock of I-City by Completion Period

The second is improvement evaluation, and by filling in the sheets using cost sheets, you can estimate in rough the cost to raise the performance that is evaluated as inferior by the present condition evaluation.

The third is use conversion evaluation, which will be carried out for buildings that were considered low performance under the current use. Probability of converting to another use will be evaluated by checking the filling sheets.

4. Case Study of Evaluation in I-city

I-city was chosen as a case study of Strategic Stock Management. I-city is situated 70km from megalopolis and has a population of approximately 50,000, which recently is slightly decreasing. Revitalization of the city center, and coping with the aging population combined with the diminishing number of children, like in most of the local cities are of the main issues of local government policy that relates to facility management.

Figure 8 shows the building stock owned by the city, by use and completion period. The total floor area sums up to 167 thousand sq meters, of which 57 thousand sq. meters (34%) are schools, 44 thousand sq. meters (26%) social education facilities and 34 thousand sq. meters (20%) public housing. There are few old public buildings over 50 years of age; mostly wooden public housings that sums up to 1600 sq. meters (1%). However, nearly half (45%, 75 thousand sq. meters) are built before the new earthquake-resistant design method came in to effect (1981) and their earthquake resistance are doubtful. The description of chapter 3 applies to the situation of stock management of the city.

Figure 9 shows in radar chart the result of performance evaluation trial for 6 facilities that are taken up for group management in chapter 5, out of 13 facilities where evaluation is carried out. Through the evaluation trial, evaluation by the filling sheets has shown effect in the following points and proved to be practical.

- The whole public building stock of the municipality can be evaluated. By evaluation of administrative staff member team themselves, grasping and solving of the problem of the whole concerned with the facilities becomes possible.
- A specialist was asked separately spending time and expenses so far, but as for this method, where a specialist are found to be necessary, they can be asked and examined afterwards.
- Evaluation of whole of the facilities which was difficult so far can be carried out in comparatively short time and quantitative data accumulation, building index preparation and similar example comparison become possible by carrying it out once every five years, and they can be set up as a bench mark.
- Efforts to renovation and conversion will become easy.

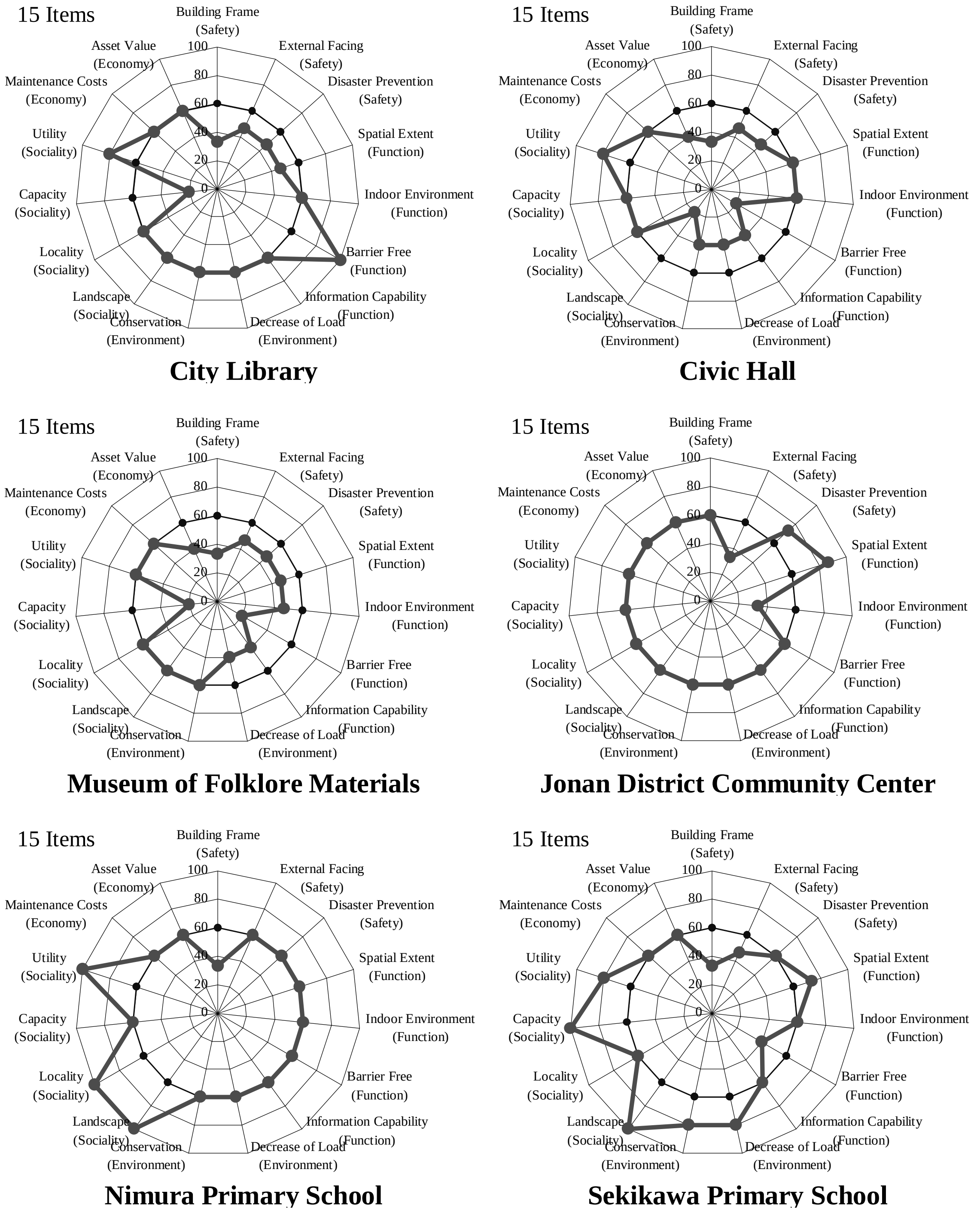

Figure 9: Performance Evaluation of I-City Public Buildings

5. Case Study of Group Management in I-city

After each public building has been evaluated, group management of the facilities will take part. The objective of group management is to examine and compare the change of function level and the social impacts of a set of management plans; maintenance, repair, conversion, rebuilding and new construction; of facilities in the management unit, and to choose the best according to higher policy. Generally, consideration of group management will take the following steps.

A. Preparation
- (i) Sort out of the present condition of the facilities
- (ii) Sort out of the presuppositions and scenarios of the group management
- (iii) Evaluation of the buildings that are considered in the scenarios
- (iv) Population forecasting

B. Examination of each scenario
- (i) Arrangement of public facilities improvement plan of the area
  - a) Review of public facilities improvement plan
  - b) Consideration of future maintenance and renewal of facilities
- (ii) Estimation and levelling of future financial burden for maintenance and renewal
  - a) Estimation of future financial burden
  - b) Levelling of future financial burden
- (iii) Cost benefit measurement and impact analysis of the scenario
  - a) Economic ripple effect measurement
  - b) User benefit (level of service) measurement
  - c) Environment load measurement
  - d) History and culture consideration

C. Comparison of scenarios

In the case study of I-city we have examined 3 cases of group management, but hereafter, the first and second will be referred to.

The first case is rearrangement of facilities triggered by a large scale cultural facility. The existing city library of I-city was built in 1980. Despite the floor area of 1,521 sq. meters, it was originally planned to shelve 500 thousand books, whereas at present the collection is 1,500 thousand. The City's original plan to cope with was to build a new cultural complex with a new library which can shelve 3,000 thousand books, under the circumstances then that the City will amalgamated with other 3 adjacent municipalities. The reality now is that the amalgamation is with only another, and there is need to consider optional plans.

Under the circumstances, we have set up 3 scenarios (Figure 10): 1. Repair and prolongation of the present library. 2. Enforcement of the complex cultural facility plan and use conversion of buildings after removal. 3. Control and distribution of demand level to the present facilities (only the southern part of the city is studied).

Figure 11 and 12 shows the occasion, details, and expenditure (excluding subsidies for new facility) of maintenance and management for relational facilities of each scenario after the levelling process. Including the results of social impact evaluations, the conclusion was that by utilizing present facilities, with as much cost as for improvement of present library, and far less than for a new one, improvement of user benefit, high level of local economic ripple effect measurement and decrease of environmental load will be possible.

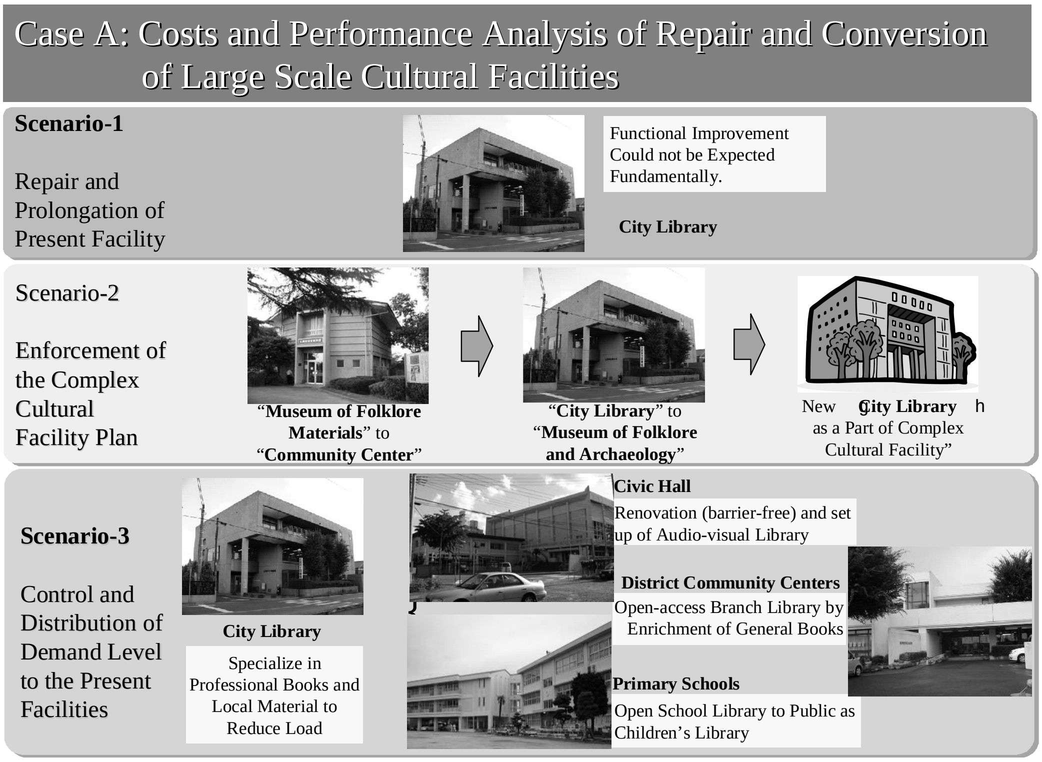

Figure 10: Group Management Scenarios of Case A

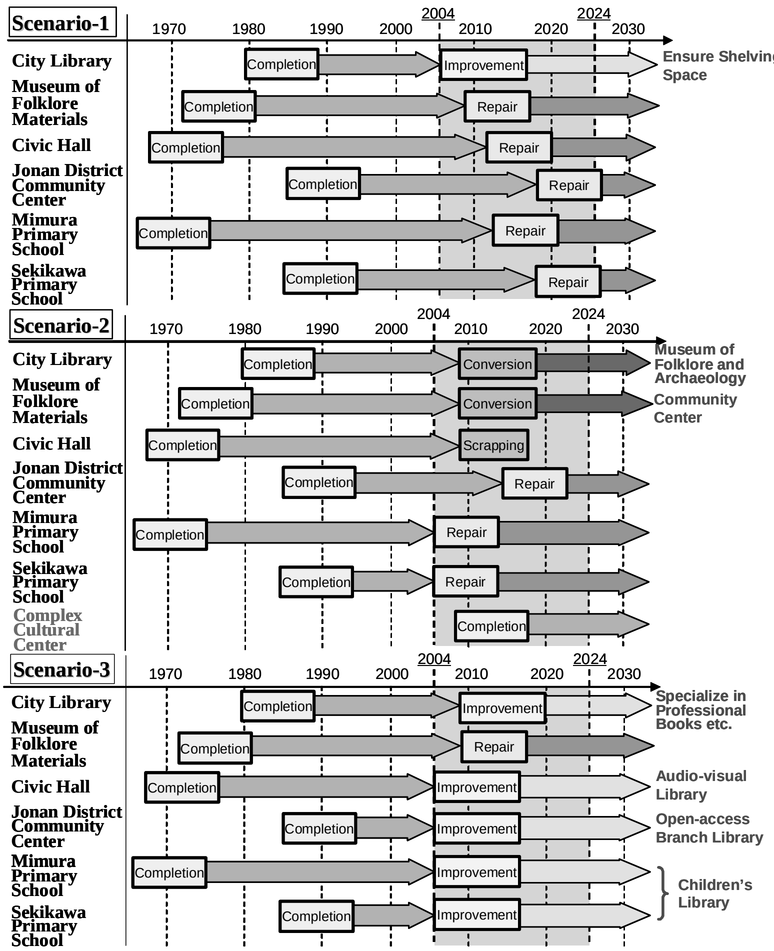

Figure 11: Maintenance & Management in Case A

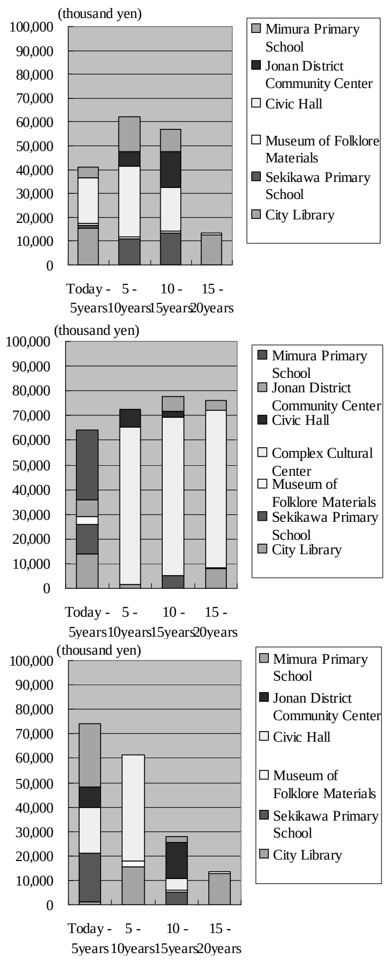

Figure 12: Expenditure of Case A

The second case is preparation of small-size close-to-life day-care welfare facilities. Under the progress of nationwide aging society and increase of nuclear families, the need for elder care facility is growing. The traditional provision of the facilities were, construction of a large scale multifunctional welfare center, whereas need for small-size close-to-life welfare facilities to support home nursing care is increasing. In I-city too, a large scale facility has been built in a northern rural part of the City, and there is growing need for smaller ones.

For this case, we decided to study about the southern part of the City and we have again set up 3 scenarios (Figure 13), including the traditional style: 1. Construction of large scale multifunctional welfare center. 2. Construction of (two) new regional welfare facilities. 3. Distributed welfare service by utilizing present community centers.

Figure 14 and 15 shows the occasion, details, and expenditure of maintenance and management for relational facilities of each scenario after the levelling process. Including the results of social impact evaluations, the conclusion was that utilizing present facilities (scenario 3), was a little costless than the others, the local economic ripple effect measurement was higher, and decrease of environmental load was greater, and by utilization, improvement and repair of village community centers will be possible as a public project (else left to the community).

6. Conclusion

Targeting small and medium size local governments whose building stocks, under the financial and manpower problems, are not well utilized effectively, we have developed a method to evaluate present performance level, upgrading of performance by improvement and its cost, and possibility to convert to use of more demand, of the buildings by in-house staff members simply. Another development is, using the result of the evaluation, and a group of facilities in the area as an object, methods to design a number of optional maintenance and management plans, guided by higher plan and change of socio-economic conditions, and evaluate and compare the upgrading of facility's performance by improvement, cost and spending and social impacts under the plans, and to choose the adequate one, which in total will facilitate optimization of total cost, environmental load, and service level. The case studies in I-city has given its concrete example, and proved to be effective.

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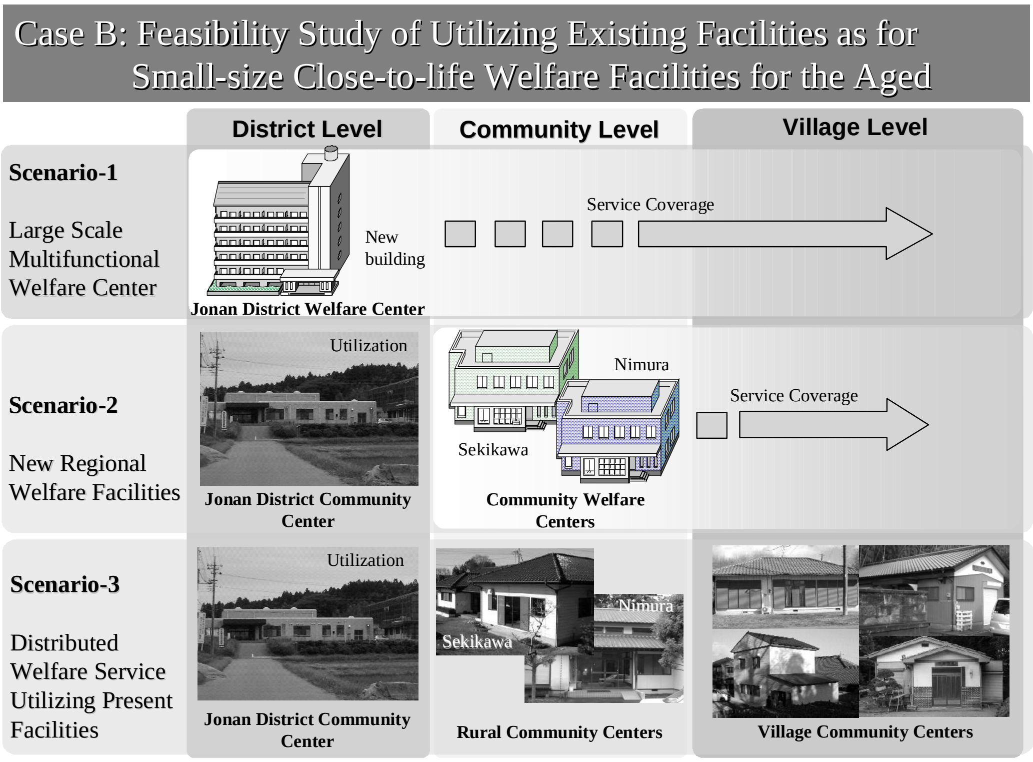
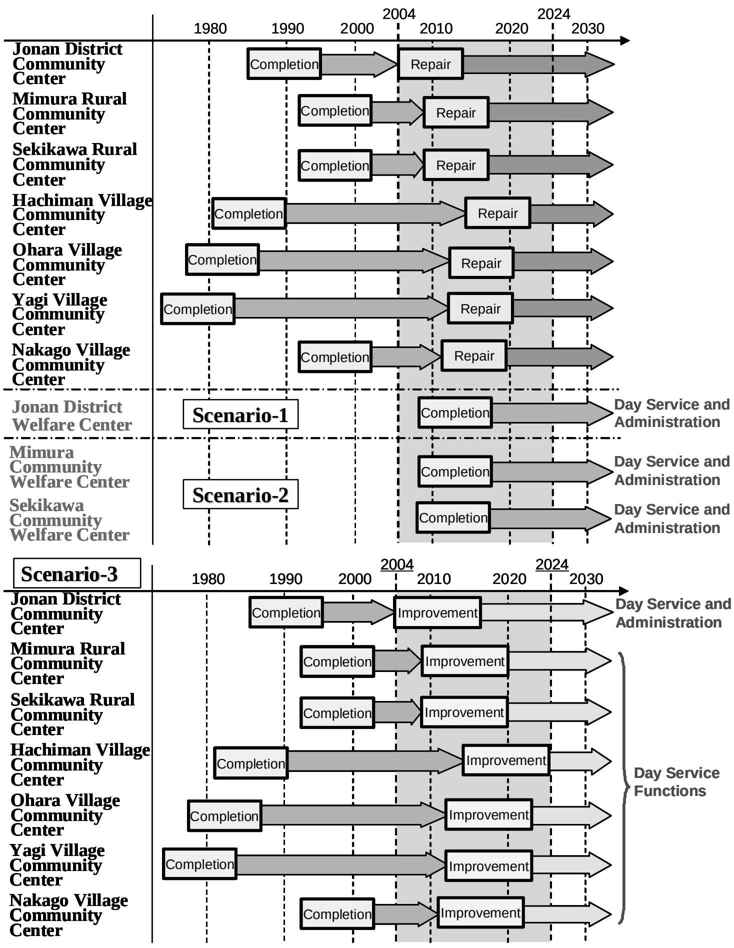


Figure 13: Group Management Scenarios of Case B



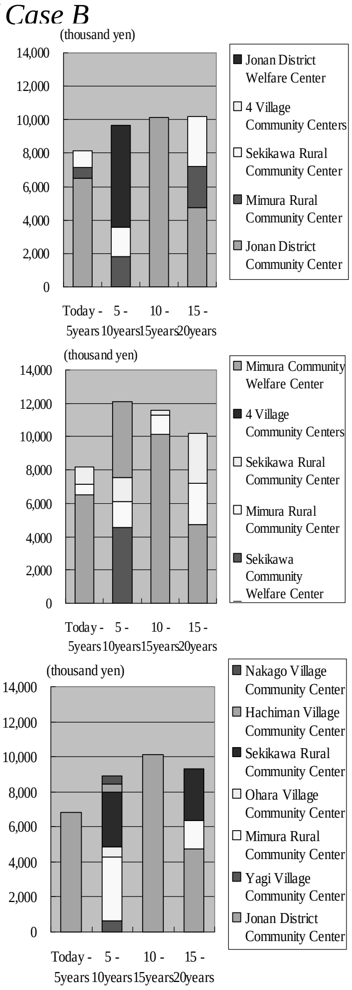


Figure 14: Maintenance & Management in Case B

Figure 15: Expenditure of Case B

The FM Industry and Adding Value for Clients

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Abstract

Many writers on FM stress the importance of the role FM should take in enhancing business performance. So far, the idea that FM itself is essentially strategic in nature, rather than operational, has not been widely accepted by senior management. Different writers take different approaches to this and there is no lack of ideas on how FM can be linked to business performance. This paper argues that the key issue is to help organizations increase the value gained from their use of the space that facilities provide. For the FM industry to significantly change the role it performs for clients and become a strategic rather than operational function will require a long-term approach using four approaches to value-adding for clients. This would be a major change in direction, both for the industry and the perception of FM by clients.

Keywords: Facility management, industry growth, value-add, strategic function

1. Introduction

The task of delivering 'value for money' is an important part of facility management (FM), but it is often not clear what 'value' is in the context of FM. Many writers on FM stress the importance of the business environment and suggest that there is a strategic role for FM in enhancing business performance. This would certainly add value. However, despite the importance of the workplace as a strategic management tool Price (2001) argues those involved in property and facilities, whether in research or professions, do not know how to describe themselves in terms of strategic value added. In his view "buildings operations and maintenance contracts dominate the FM market place. FM practitioners tend to focus on managing costs rather than thinking in terms of adding value" (Price 2001: 1).

While the idea that businesses use their facilities as a strategic resource is not controversial, the claim that FM itself is essentially strategic in nature, rather than operational, has not been widely accepted by senior management. FM is frequently referred to in the context of providing support to business. This divergence of views has encouraged a debate over the future development of the FM industry.

This paper first looks at the debate over the future of FM. In this debate the different directions the industry could, or should, take in its development have been identified, often reflecting different ideas held by these researchers on what FM actually is, or should be. Secondly, the paper considers the relationship between the growth of FM as an industry and the role that the increased use of outsourcing has played in that growth. There is a brief discussion on the nature of value to clients and building owners. This leads to the main contribution of the paper, identification of the four approaches available to the FM industry that can improve its ability to add value for clients. The conclusion sums up these points.

2. The Debate over Future Directions

There has been an ongoing discussion about the future development of FM and the role FM should take in enhancing business performance. While the idea that businesses use their facilities as a strategic resource is not controversial, FM is often seen in the context of providing operational support and the claim that FM itself is essentially strategic in nature has not been widely accepted by senior management.

Different writers have taken different approaches to this. Duffy and Tannis (1993) emphasise the role of workplace design and productivity. O'Mara (1998) is concerned with the drivers of corporate change and development. Alexander (1996) sees FM as enabling organisational effectiveness, and argues for FM to be 'an enabling mechanism which responds to the evolving needs of business' His belief is that the discipline should not be mistaken for a support function. Becker and Steele (1995) carry the workplace ecology argument through to its logical conclusion. Finally, McGregor and Then (1999) make the case that FM is the 'business of space' and Tay and Ooi (2001: 360) claim that "the core competence of a facilities manager is strategic level FM matters while overseeing operational matters … FM must play a bigger part in overall business development, becoming a strategic rather than operational issue".

This range of ideas is matched by the diversity of opinion on what FM is. Tay and Ooi (Table 1 below) reproduce eight definitions that vary from the comprehensive approach of Alexander (1999) or Nutt (2000) to the workplace and business focus of Becker (1990), Then (1999) and Varcoe (2000). Out of these ideas a debate about where FM is going, or should be going, has developed.

Nutt (2000) starts with the statement "the strategic objective of facility management is to provide better infrastructure and logistic support to business and public endeavours of all kinds across all sectors". Again, here is the emphasis on strategic aspects of FM that is not found in practice. Nutt identifies and discusses four basic trails or pathways to the future which are explored. These correspond to the generic types of resource that are central to the FM function: the management of financial resources, human resources, physical resources, and the management of the resources of information and knowledge.

The ideas and analysis that underpin the four trails are important and interesting. It is not clear, however, that they establish a genuinely strategic role for FM, rather than a complex operational role with some longer-term aspects. What the trails identify is the range of core areas for FM, and how developments in technology, work patterns and so on will challenge the industry to develop these core areas over the next couple of decades. In themselves, the trails will not provide the basis for a strategic role for FM, although the opportunities for making powerful contributions based on one or more of the trails are there for taking. Also, the four resource trails seem likely to be subject to radical change towards 2020, with a wide range of possible futures. While the trails share a common objective - to provide strategic and operational support to all of our endeavours - they work to different agendas, serve different interest groups, with conflicting priorities and ambitions.

Table 1. Sample of FM Definitions

Author	Definition of FM
Becker (1990)	FM is responsible for coordinating all efforts related to planning, designing and managing buildings and their systems, equipment and furniture to enhance the organisation's ability to compete successfully in a rapidly changing world
Nourse (1990)	FM unit is seldom aware of the overall corporate strategic planning, and does not have a bottom line emphasis
NHS Estates (1996)	The practice of coordinating the physical workplace with the people and work of an organization; integrates the principles of business administration, architecture, and the behavioural and engineering science
Alexander (1999)	The scope of the discipline covers all aspects of property, space, environmental control, health and safety, and support services
Then (1999)	The practice of FM is concerned with the delivery of enabling workplace environment – the optimum functional space that supports the business processes and human resources
Hinks and McNay (1999)	… common interpretations of the FM remit; maintenance management; space management and accommodation standards; project management for new-build and alterations; the general premises management of the building stock; and the administration of support services
Varcoe (2000)	… a focus on the management and delivery of the business 'outputs' of both these entities [the real estate and construction industry]; namely the productive use of building assets as workplaces
Nutt (2000)	The primary function of FM is resource management, at strategic and operational levels of support. Generic types of resource management central to the FM function are the management of financial resources, physical resources, human resources, and the management of resources of information and knowledge

Source: Tay and Ooi (2001: 358)

For Duffy the history of facilities management has been one of rationalisation. As the discipline developed cost cutting became the predominant objective and the chief distinguishing feature of facilities management in practice. What could have happened was the linking of design and FM, but after twenty years this link has not been established. "What has happened has been very different from what we expected. The skill of managing office space may have developed but the office environment itself remains very much as it was." (Duffy 2000: 372). He sees the challenge as being using design to achieve business goals, and this will require the reinvention and the reintegration of the entire business of design, construction and space management.

Duffy has highlighted the dilemma under discussion. A greater link with design and development of workspace would give FM the strategic role that is being sought. Design is early stage, planning intensive work and involvement here by FM practitioners would deliver strategic significance. However, once again the fact that this is not the case illustrates how difficult it will be for to achieve place in these strategically important stages.

Bon et al (1998) argue that corporate real estate management (CREM) requires an organisational structure that stimulates interaction between researchers and practitioners of CREM. They conclude that the development of management tools for CREM will require close collaboration between researchers and practitioners, with much of the research being conducted by CREM practitioners themselves. Performance measurement is one of the first steps in this direction. Therefore, the most important task is the development of management tools that can help close the feedback loop between managerial action and property performance.

A research intensive approach has much to recommend it, particularly in regard to medium-term improvement in the industry's performance. Will this also deliver strategic relevance? That probably depends on the scope, scale and focus of the research. However, practitioner led research is likely to go down the operational path the industry is already following, if for no other reason than that would be what appeals to the industry's clients.

Price (2002) argues for FM to be more focused on business language and a move from performance measured in terms of outcomes to performance considered in terms of outputs. His evolutionary perspective, also found in Price (2003), suggests that FM has yet to find its place in the marketplace for both ideas and business services. In many ways this sums up the key elements of the debate over the future development of FM rather well, given that FM is typically an outsourced function. In fact, the success of FM as an industry has been closely tied to the growth of outsourcing.

3. Outsourcing and the FM Industry

The response of many large organisations to the increase in demands for better performance, global competition or pressure on their balance sheets was to identify core activities and outsource as much of the rest as possible (Incognito 2002). Indeed, the growth of FM as an industry has been underwritten by the increasing use of outsourcing for non-core functions as business put the ideas of Hamel and Prahalad (1994) into practice. This has been crucial in establishing FM as an industry sector in its own right as organisations moved responsibility for asset management to specialists (Katsanis 2003).

However, if FM is largely responsible for managing an outsourced part of business operations (the use of physical space), how can it be included in the management tasks given to the senior executives responsible for strategic planning for these businesses? In this case, the success of FM will deny it the chance to become the strategic contributor to business performance that so many have claimed for it. Indeed, the more successful FM becomes at taking on and managing an outsourced function, the less likely it becomes that it will be included in the higher councils of management decision-making and strategy. Further, if FM is not included at this level of decision making, how will it be able to increase the value it adds for clients?

The argument for outsourcing is typically based on the perception of cost savings and improved quality. This comes through reduced capital outlay on facilities, manpower and equipment for the client while the provider is responsible for updating and maintaining equipment and technology. Other commonly recognised advantages of outsourcing include freeing up of resources, variable capacity, knowledge transfer from outside specialists, economies of scale by vendors, and it is particularly suited for specialised or risky operations (Embleton and Wright 1998). Outsourcing is seen as a means of concentrating an organisation's resources in its core competencies (Campbell

1995). May (1998) argued that many organisations spend a disproportionate amount of management time managing non-core activities and that outsourcing can increase competitive advantage.

The growth of FM as an industry has been driven by outsourcing, and the future growth of FM will also be driven by outsourcing. There are still large industry sectors where FM is done in-house, higher education is a good example. As clients become more comfortable with using contractors to supply specialist services and the FM in industry becomes more sophisticated in its marketing, customer relations and performance measurement, the potential for continued growth is clear. There is of course a countervailing tendency of clients to take some functions back in-house due to reassessment of importance of technical requirements (Luciani 2005), but the overall trend should be toward more use of outsourcing in certain client industries.

While the figures for outsourcing and views on these advantages and disadvantages would vary across countries and industries, they reinforce the argument that the scope for growth of the FM industry through outsourcing is enormous. However, the problem of strategic relevance found in the current situation thus appears in the future for FM, with the same fundamental cause: managing an outsourced function may be important, but it is not strategic. If the future growth of FM is tied to the increased use of outsourcing, as growth in the past has been, the challenge for FM to become a key part of an organisation's strategic planning will become greater. Growth in the size or the turnover of the industry will not, in itself, solve the problem.

The opportunities that design integration, workspace management, research focus or the four 'trails' identify are more like extensions to the outsourcing based growth path rather than full alternatives. Extensions because they add depth to the outsourcing based model, but do not add breadth or offer a substantially different growth path. How to deliver different forms of 'extended outsourcing', where there are more of the higher value-added services present in the outsourced package, may be the key challenge in the future of FM. But what is value in the context of buildings and structures?

4. Value to Clients and Owners

How do buildings create value for construction industry clients and building owners, and what is the role of the FM industry in maintaining or adding value to clients and owners? That clearly depends on what particular concept of value is to be applied, out of the range that are possible.

Best and de Valence (1999) suggested that, for buildings, the forms of value include: utility; use as accommodation or for income; exchange or sale value; esteem, prestige or iconic value; and a quality-cost-functionality relationship (pp. 14-17). Similarly, Spencer and Winch (2002) cover three broad sources of value: financial value, based on capital and operating costs and investment value: business processes and the people, space and productivity matrix; and the symbolic and aesthetic value of buildings. There are many other variations on these ideas (see for example Kelly, Morledge and Wilkinson 2002).

For the FM industry, the idea of value has to be strongly related to the performance of the space occupied by the client, in the client’s terms. This makes a ‘one size fits all’ definition of value difficult to find, because clients come in many shapes and sizes, with a wide range of requirements and levels of service demanded.

5. Adding Value

How can the FM industry improve its ability to add value to the way businesses approach the role, function and use of physical space? One way of responding to this challenge is to break the answer down into several parts, like a puzzle the industry has to solve. Four distinct but interrelated approaches to adding value for FM clients are identified and discussed below.

The first approach is based on the idea of business performance itself. Despite the emphasis placed on this, it is neither obvious nor constant. Both how performance is measured and how it is rated change over time. For example, the impact of Kaplan and Norton's (1996) idea of the 'balanced scoreboard' has been significant. Likewise, the growth of 'triple bottom line' reporting (financial + social + environmental results). Other measures that are widely but not universally used include R&D, innovation or revenue from new products, market share and financial ratios such as return on equity, revenue and profit growth. The implication here is that the specific indicators a FM client uses to measure performance need to be understood and targeted by the FM provider. Further, the particular measures applied to facility use and performance need to be developed for each client and made relevant to the client's business practices and objectives.

A second approach to the problem is the changing nature of strategic planning. The detailed, prescriptive form of business planning is no longer popular, and what is considered strategic in business also changes over time. When Jack Welch became CEO at GE in 1983 one of his first actions was to close down the strategic planning department (with 200 people), and start the annual seminar series at Crotonville that became the foundation of GE's success (Welch 2001). Mintzberg (1994) discusses the history of strategic planning in business, and argues that neither business planning nor strategic analysis are any less important now than in the past. It is how these are done that creates their relevance or lack of it. The opportunity here is for the FM provider to apply the specialist expertise and experience gained from improving facility performance and to identify how value can be added for clients in the long term, through more innovative design, use and management of facilities.

A third approach to meeting the challenge concerns the development of the industry. Tay and Ooi (2001) suggest a number of areas for theoretical development in FM (see Table 2 below) and three main building blocks of FM professionalism. First, FM as a discipline must be clear on its roles in industry and in organizations. Second, for FM to be taken seriously by management it has be a contributor to profits and manage facilities to enhance performance of the firm. Thirdly, FM must develop its own specialist knowledge and toolbox in managing the workplace across six areas, with an emphasis on workplace performance and performance measurement. They conclude that FM remains reliant on management and technical knowledge from other fields. The FM industry needs to establish a core knowledge base and the techniques available for its application.

Reliance on management and technical knowledge from outside FM is not in itself a problem, especially in a time of positive externalities from knowledge, an emphasis on training and human capital, and increasing returns from the effects of network economics on industry. Perhaps the challenge has more to do with sorting the wheat from the chaff in management ideas, not getting distracted by management fads and buzzwords, and coping with information overload with so many business management books being published.

Table 2. Suggested Theoretical Developments in FM

Scope of FM	**Suggested areas for theoretical developments**
Location	Developing a model for locational decisions Studies on the relationships between locational choice and business performance
Type	Understanding workplace requirements for various facility users, e.g. schools, hospitals, factories, etc.
Quantity	Developing a model to forecast space requirements
Quality	Performance measures to assess the quality of workspace Developing performance standards
Allocation	Studies on emerging work patterns and their impact on space allocation
Content	Studies on the relationship between content layout and work performance

Source: Tay and Ooi (2001: 362)

Finally, the fourth approach is the type of contribution FM makes to its clients. Profit margins can be increased by either driving down the cost of products and services, or by pushing up their value and increasing the price customers' will pay. The strategic objective is to maximise the difference between value and cost, and to build value which customers perceive to be better than that offered by competitors. For most businesses changes in revenue presents both the greatest opportunity and the greatest threat, and is more significant than major costs such as staff, technology and equipment and occupancy costs. Therefore there are greater opportunities to improve organisational performance through revenue and productivity improvement rather than through cost reduction and the risk to revenue and productivity due to poor facility design and management is far greater than the expense of building or occupying space.

Lower facility costs lead to lower production costs, and to reduce occupancy costs organizations can take a range of measures, such as re-negotiating leases, teleworking and hotelling and lowering the workspace ratio (Turner and Myerson 1998). The workspace ratio varies between industries, for example the Property Council of Australia found the financial services sector averages about 15 square metres per employee and the legal sector averages 20 square metres per employee. For any organization there is some level of optimal space efficiency (Smith 1999). Another factor that is important in industries undergoing restructuring and 'creative destruction' is reducing the cost of churn (relocating employees). For firms in these industries the cost of churn can be as high as rent. Space can contribute to strategic change through aligning facilities with organisational objectives, structure, cultural values and workstyles. Finally, organizations continually seek ways to reduce capital costs of buildings, but capital expenditure is minor when compared to costs over the life of the fitout and services. The issue here is maximising the benefits of capital spent to get the best return possible.

On the value side, strategic decisions on property location, space forecasting and usage are important. However, what is crucial is how FM can contribute to developing the competitive advantage of the firm, particularly for firms or organisations attempting to enter new markets or confront global competitors. These firms are typically increasing their efforts to innovate and to develop new products or services. Also, facilities can be a source of competitive advantage if location or amenity is a barrier to entry for potential competitors

Organisations are also looking for work environments which improve productivity and efficiency, support innovation and learning, allow introduction new ways of working, increase information exchange and accommodate a diversity of management and work styles (Zelinsky 1998). The pressure to achieve higher productivity through use of teams with more effective means of communication, both electronically (through bringing different departments together) and spatially through workplaces designed to encourage increased group and shared working patterns, is one of the great opportunities for FM to add vale to clients.

6. Conclusion

Organisations spending money on the renovation or maintenance and use of a building try to get value for money, usually within a fairly clear budgetary framework. Those who authorise the expenditure will be looking at how much is spent, what return can be expected and how satisfied they will be by the outcome. The task of FM is to help users get the most benefits from their properties and facilities.

There has been an active debate over the future direction and development of the FM industry. This debate has highlighted a number of key issues for the industry, but also bought out the wide range of approaches taken by participants to both these issues and the appropriate role of FM.

This paper has argued that, if the FM industry is to significantly change the role it performs for clients and become a strategic rather than operational function, it will require a long-term approach focused on value-adding rater than cost saving. This is a major challenge, both for the industry and its clients. This paper then identified four distinct but interrelated approaches to adding value for FM clients.

The first approach involves performance measurement. By developing specific measures of performance to apply to facilities, to be targeted by the FM provider the industry can help organizations meet a range of performance criteria. These will vary between organizations and will typically be customized to take into account the location, purpose and strategic significance of the facility. Establishing for each facility this strategic significance could be the means to become relevant to and provide input to organizations' strategic planning.

The second approach is to increase this strategic relevance of the FM provider’s contribution to the client’s business practices and objectives. The opportunity here is to identify how value can be added for clients in the long term, through more innovative design, use and management of facilities.

The third part is developing FM professionalism. This involves the use of analytical tools for locational decisions, space use, work patterns and other characteristics of the modern work place. The objectives of this analytical approach are to help organizations lower occupancy costs and increase the value gained from their use of the space their facilities provides. This is the fourth and most important part of the answer. In a world of ever-increasing competitive pressure and shorter product cycles, value creation is the key to survival for many organizations. By making itself an integral part of the value creation process, FM will become a strategic function.

Until recently few organizations paid much attention to how the planning, design, and management of their buildings and associated systems, equipment and furniture affected the organization's ability to meet its business objectives. Information technology and competition, which have driven organisational changes, have placed new demands on organizations' physical resources, increasing awareness of the importance of FM. As this has happened, the role of the facility manager has grown to include more than the maintenance of the physical structure of the workspace. There is an opportunity to shift the emphasis from controlling the cost of occupying and using facilities to the contribution of the workspace and its infrastructure to the productivity of the organisation and the efficiency with which it uses its resources. This fourth approach would allow the FM industry to add significant strategic value to the operations of clients.

Therefore, the opportunity exists for the FM industry to increase its strategic relevance to clients. The idea that businesses use their facilities as a strategic resource is not controversial, but because FM is typically an outsourced function the idea of FM as strategic, rather than operational, has not been widely accepted by clients. Different writers have taken different approaches to this and there is no lack of ideas on how FM can be linked to business performance. This paper has argued that the key issue is to help organizations increase the value gained from their use of the space that facilities provide. For the FM industry to significantly change the role it performs for clients and become seen as a strategic partner, rather than as an outsourced operational function, will require a long-term approach focused on value-adding rather than cost saving.

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Change Management within FM

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Abstract

FM is always related to changes: Changes within the core processes having impact on the requirements for facilities, changes in technology and processes demand higher productivity and effectiveness. However, in contrast to the core business, methods of classical change management and process re-engineering are not yet applied in Facility Management.

This paper shows how classic methods of change management, process modelling and re-engineering can be used in the field of Facility Management. It presents a theoretical overview about the current methods and describes their advantages and disadvantages.

In the second part, the usability of these methods within FM is analysed. In about 20 case studies with companies the methods for process modelling and re-engineering were tested in practice. The results of the case studies are presented. Based on the results, adaptations and further developments of the current concepts to improve their usability within FM are pointed out and a new methodology based on classical process modelling and re-engineering methodologies is presented.

The new methodology ensures that the strategy of the company as a whole and the strategy in respect to facilities are taken into account. It also ensures, that all relevant processes are defined and the necessary changes in organisation and ICT are identified and implemented in a proper way.

This methodology has already been used in case studies and proofed its usability.

Keywords: process optimisation, process re-engineering, IT and organisation

1. Introduction

Within all industries modern companies have to change to survive in a rapidly changing world. Whereas 30 years ago an employee did the same job for his whole work-live, today’s employees have to adapt to new situations and tasks quite often. Project orientation and new forms of collaboration led to more flexible forms of organisations. Today it is common to change the team and the workplace at least once a year. In some industries like telecommunication changes happen even more often. These changes also have impact on the core FM processes.

In most cases changes and optimizations within the core processes are carried out by using the methodology of business process reengineering. Business process reengineering can trigger the necessity of structural measures in order to provide the required infrastructure, can lead to changes in technology and trigger processes within FM. Therefore, process optimisation projects contain, apart from the usual activities of process optimisation, also the matching with the infrastructure. This is an iterative process, changes in the core processes lead to changed requirements for infrastructure, which offer altered framework conditions for the core processes. This can lead to changes and opportunities within the core processes. An optimum organisation for these highly dynamic and complex planning projects consists of the following teams (extended project team; see [1], p. 145):

- the team for an optimisation of the core processes, mostly lead by the organisation development;
- the team for the planning of the infrastructure (building, systems, etc.), lead by the process controller of the planning process;
- the controlling team with the task to safeguard the co-ordination of both teams.

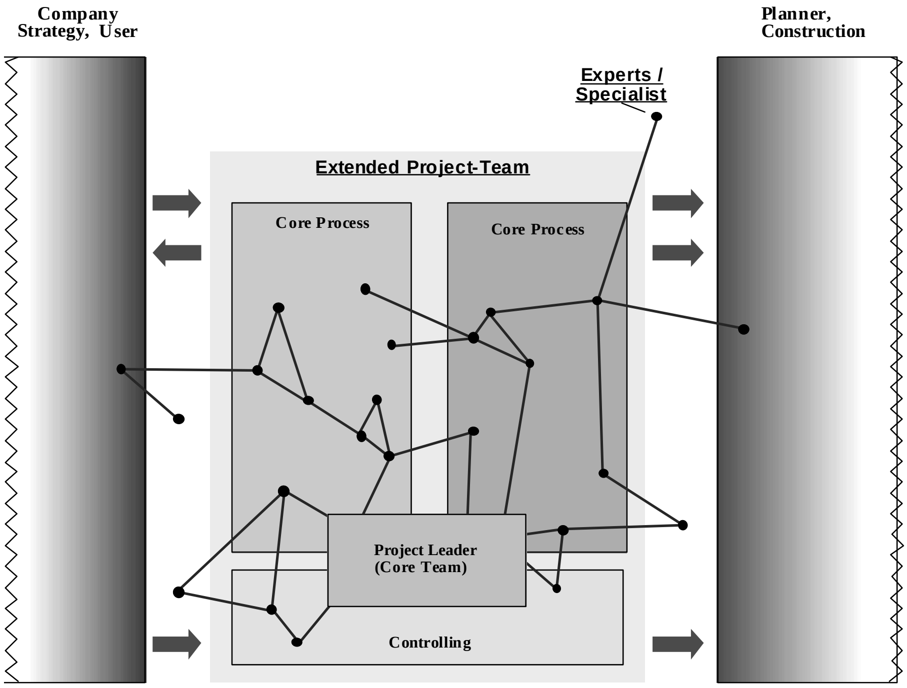

Figure 1: Organisation of highly dynamic and complex planning projects [1], p. 145

These teams are subordinated to an overall project leader, the overall process controller. He has to safeguard the comprehensive cost-benefit optimisation of the project. Today traditional planners cannot perform these tasks and are often not accepted in this role by the owners of the building, because they lack the knowledge of process optimisation. However, there is already an approach of planners towards this role. Some companies, such as Bene Consulting or DOMUS FM, already perform process analyses in order to merge the results into programming. But these planners do not perform an optimisation of the core processes or do not even trigger optimisation. Therefore, their approach lacks optimisation of core processes, but they cover the remaining activities of the process controller.

Traditional organisational consultants also cannot fulfil the tasks of a process controller in a comprehensive manner, because they lack experience of the planning of the infrastructure. A further potential process controller is the facility manager. He frequently assumes the role of the process controller for the planning of the infrastructure in case of utilisation by the proprietor. He is seldom given the task of optimisation of the core processes, although in some FM definitions also the tasks of personnel development are allocated to the facility manager. The future will show who is able to assume the comprehensive role.

Besides this question, who should carry out the tasks, there is another question, an even more interesting. It is about the methodology to be used for the optimization of the FM processes. In literature there are no guidelines. Therefore a team of researchers from the Viennese Technical University searched for methodologies employed in the core processes. The most widely spread and accepted one is business process reengineering. Therefore this methodology is analysed in detail within the next section.

2. Business process reengineering

A few years ago, most companies were organised according to Taylor. Work was splitted up in small tasks, being carried out by specialists. Between this specialists there was a lack of communication. There were even communication barriers. It was almost impossible to reach goals of time-, cost-quality and innovation leadership. Therefore, a change took place within most of the organisation.

The companies began to define their core competences. The core competences of a company are the specific abilities, which differentiate a company from others. Thus, as a basic data source to determine their core competence, they used the analysis of the needs of the customer, market analyses, analysis of the own potentials and benchmarking with the competitors in the industry.

Based on this, business process reengineering was used to “optimise” the core processes. Business process reengineering leads to a fundamental rethinking of the processes within a company. The goal of this rethinking is to gain time and cost reduction. This leads to a new conception of the work/tasks which have to be done.

Instead of Taylorism, which is characterized by the division of the work into small tasks carried out by different specialists, business process reengineering combines tasks, that belong together, to larger process steps. These lager steps have to be carried out by one person instead of many (comp. [2]). The main goal of business process reengineering is to define simple processes with few interfaces by creative reintegration and redesign of the core processes (comp. [3], p.5 and p. 49]). This also means a change of the organisation. The current horizontal organisation is changed into a vertical organisation characterized by team work.

The base line for all these changes are the needs and expectations of the customers. By changing the organisation (processes and company organisation structure) the company should be enabled to provide a better service to the customer according to his needs, and should be easily capable of adapting to changes in the customer’s requirements. In order to be able to carry out these changes the general management has to support these activities.

According to business process reengineering, the change process consists of the following parts ([3] p.42):

Renewing: In this step the needs of the customers are analysed and new business areas are defined (comp. [4], [5] p. 34ff, [6])

Relocating: In the next step changes of the location and production methodology are to be defined (comp.[7] p. 286ff, [8])

Reengineering: The next step represents the core business process reengineering, which includes the redesign of the core processes and the change of the company organisation structure (comp. [9], [10], [11])

Revitalizing: The next step is to develop the knowledge of the employees (comp. [12], [5] p. 251ff, [13], [14])

Reframing: The last step is to realize the mental change by changing the subjective behaviour (comp. [15], [16] p.116 ff)

Business process reengineering itself consists of the following steps (comp. [3] p. 50):

Communication of the necessary changes: The communication of the goals and areas of changes has to be done by the board of directors. In this step the teams and the process owners have to be defined for each process. This step should give confidence to the middle management, trade union and the employees. Change can often lead to fears about employment which leads to opposition to change.

Identification of the core processes: The core processes which are important for the success of the company have to be defined. Basis for the estimation of the importance are descriptions of the processes at a high abstraction level.

Selection of the core processes that have the highest need for change (not working properly, causing problems, not fulfilling customer needs, possibility to change processes): This step also includes the definition of more detailed goals for the selected processes regarding time, cost and quality.

Analysis to understand processes: This step is based on workshops, interviews and observations. It is quite often supported by external consultants as they might bring in new ideas.

Collect ideas for redesign and optimization: This step is carried out together with the process team and internal/external process specialists to find new ways of carrying out processes.

Development of concept: Based on the gathered knowledge and ideas a concept for the optimization of the core processes is defined. This concept includes the process steps, the organisation and the ICT support. In this step the following principles have to be taken into account:

- Relocation of decisions to working level
- Definition of tasks per organisational unit in a way to reduce interfaces
- Reduction of controls
- Combination of organisational units

Coaching of process owner: The last step is the coaching and training of the process owner and his team, so that they are capable of taking over the new tasks and responsibilities.

All these steps should follow the core principles [9]:

- Follow the natural sequence of process steps
- Definition of process variants (e.g. simple/difficult task)
- Redesign of customer contacts
- Introduction of a responsible person for all customer contacts to co-ordinate all tasks carried out for each customer
- ICT to enable new solutions

The change process based on the results of the business process reengineering can be carried out in two different ways:

Firstly by a radical change of a few core processes (American attempt comp. [9], [17], [18]) or secondly by a continuous improvement within the current structures according to Kaizen and [19] (Japanese attempt).

The American attempt leads to a lot of problems with the employees who often oppose to the changes. It also causes problems with the trade unions as they fear that the changes cause the loss of jobs. The Japanese way often cannot reach the goals as changes happen very slowly and the final target can only be reached after a long period of time.

Combining these two extremes leads to the European way of change management by business process reengineering. The European way makes changes step by step and in this way the whole company is changed and not only a few core processes. It also includes tasks to change the habits and the qualification of the employees (comp. [20]). This European way of change management is also called evolutionary change management.

3. Advantages and disadvantages of business process reengineering within FM

For process optimisation and change management in the area of core business the methodology of business process reengineering is known and accepted. Business process reengineering provides a methodology for managing the change process. It can be used for every project within every industry reaching from production processes to office automation.

Consultants and managers are well trained in this methodology. Therefore internal or external support can be found easily. In literature best practise examples can be found for several processes within different industries.

Based on this knowlegde a research group of the Viennese Technical University applied the methodology of business process reengineering within 20 case studies. The case studies were mainly carried out in companies running office buildings. The sample consisted of different industries reaching from production industry (e.g. Beiersdorf AG), banks and insurances (e.g. Dresdner Bank, Bank Austria), energy providers, public bodies (Ministry of Finance) and hospitals to outsourced facility management companies and real estate managers (e.g. LGM, SGM, ATIS international). Their FM departments wanted to improve their efficiency and effectiveness. The goal of the research projects was to optimize their processes, organisation and ICT support. One main goal was to improve the customer orientation and in this way the customer satisfaction. The second important goal was to reduce costs.

After the first case studies the following weaknesses of the methodology within FM were recognized:

1. Business process reengineering has *not been applied to FM processes* by now. Consultants and organisation managers know the methodology but not FM. They also do not know the specific problems and drawbacks in the area of FM. In literature no FM relevant best practise can be found and there are no specific guidelines.
2. Within business process reengineering normally only external customers are taken into consideration. FM also has to take care of *internal customers* as each employee of the company is a customer of the FM department.
3. A *detailed structure or guideline* how to apply the methodology within each step *is missing*. The methodology provides an overview guideline on what steps have to be carried out, but gives no advice how the steps can or should be carried out in detail. This internal guideline is especially missing within the first step "**Communication**" and the step "**Analysis to understand processes".**
4. The *start of the business process reengineering projects was difficult*. The strategy of FM and the goals of the process optimization project the strategy have to be defined before the board can communicate them. This task has to be carried out on a team basis - consisting of the facility manager and the board. A definition of the FM strategy without detailed knowledge of the companies strategy and the board will often lead to wrong decisions as company goals and strategy have a strong influence on FM. For example when the company grows or reduces FM has to include this change in its strategy.
5. The step "**Analysis to understand processes"** mainly consists of workshops and interrogation of the employees on how they currently do their work in order to define the current processes. Therefore process modelling methodologies are used. But the business process reengineering methodology gives no advices on which methodologies fit best. A second problem is that this step takes very long and team members are often not willing to carry out the next two steps "**Collect ideas for redesign and optimization"** and **"Development of concept".** Therefore in many cases the only optimization reached within a business process reengineering project is that the actual process is supported by ICT. But this cannot leverage the whole potential of optimization.

In order to overcome these disadvantages, the classical business process reengineering methodology was enlarged in two areas.

The *value analysis* was used to provide a better general structure and guideline to the projects. The value analysis has the advantage that it can be used for any project type. It provides a clear and structured guideline how to carry out projects. By adding the parts of the value analysis to the classical business process reengineering methodology the disadvantages 3 and 4 could be solved.

To overcome problem 5 the *Scheer Architecture for Information Systems (ARIS) methodology* was applied for the steps "**Analysis to understand processes",** "**Collect ideas for redesign and optimization"** and **"Development of concept"**. This methodology is used frequently for process modelling. It supports not only modelling the processes and its steps but also includes the organisations carrying out the steps and the ICT tools supporting the steps. The use of the ARIS model without applying the business process reengineering methodology would not provide the required results as the ARIS methodology is rather restricted to modelling processes and does not include areas like strategy analysis and change management.

4. Value Analysis

The value analysis is an efficient way to optimise products and immaterial objects like processes and concepts. It was developed by General Electric at the end of the 40s as a tool for cost reduction. Since 1962 it is also used in Europe, with the goal to analyse and optimise structures of functions under the aspect of value increase. Based on this idea it soon developed to a more powerful tool than a simple method for cost reduction. In this new form it could be applied for the quick and effective generation of new concepts, but also for the improvement of existing ones. (see [21] p. 371 and especially [22] 479 f.)

According to DIN 69910 and ÖNORM A 6750-6757 the value analysis consists of the following steps:

Table 1: Steps of the value analysis

Basic Steps	Intermediate Steps	Goals
Step 1 Prepare for Value Analysis	Intermediate step 1 set up goals in rough outlines	The first step is a definition of the goals. This makes it possible to check the result of the project later. The details can be added later in the project. In the case of the FM projects this step has to be carried out together with the facility manager and the board of directors.
	Intermediate step 2 plan value analysis work	The next step is the creation of a project schedule (people, tasks, time, ..). The required persons must be selected and teams must be formed. They must be informed about the personnel resources they have to spend and the work they have to deliver for the project. This step is headed by the facility manager.
Step 2 Define Situation	Intermediate step 1 gather information	As to provide a profound basis for the subsequent work, available information must be gathered and sorted out.
	Intermediate step 2 define functions	The functions are identified and specified. The level of detail depends on the goal of the analysis.
	intermediate step 3 estimate tendencies	The market tendencies have to be estimated. This makes it possible to evaluate the probability of changes.
	Intermediate step 4 identify costs	The costs of each function defined above must be calculated.
	Intermediate step 5 define situation	The definition of the whole situation can be derived from the information above. The knowledge about functions, costs and the estimation of tendencies make it possible to describe the situation in detail.

As can be seen easily, step 2 corresponds with the steps of the business process reengineering methodology. The research team decided to integrate only the first step of the value analysis into the business process reengineering methodology but to keep the steps of the value analysis in mind as a more detailed description or guideline for the steps of the business process reengineering methodology.

5. ARIS Model by Scheer

The ARIS model is a well known modelling methodology within ICT. It consist of 4 “views” which describe the following elements (comp. [23]):

Process View: This part of the model supports the description of processes. The description can be on a very abstract level using flow charts or on a very detailed level using EPK (Ereignisgesteuerte Prozess-Ketten).

Data View: This part supports the description of the required data structure. The description is mainly done by Entity Relationship Diagrams (ER-Diagrams) showing the required entities like building, floor and room and the relations between them.

Organisation View: This part describes the organisation structure. Beside the organisational units and their structure roles are defined. A role represents employees carrying out similar tasks.

Control View: This view brings together the elements of the views described above. It shows the relations between them. That means it describes the flow of process steps, describes which process step is carried out by which organisational unit (role) and defines which step is supported by which ICT tool.

The methodology can be used to model the As-Is status of the processes and the Should-Be status.

6. New methodology

In the course of the case studies it was found out that there is the danger to model the As-Is status in strong detail. This procedure takes a long time. As the team members have to carry out their “normal work” beside the project they become tired. As a result, when the As-Is analysis is finished, they are not willing to support the next steps. As a solution for this problem the research team combined the steps “**Analysis to understand processes”** and “**Collect ideas for redesign and optimization”**. This was done in an easy way. The process steps not being carried out properly or being missing at all were included in the As-Is analysis, but they were marked with a red colour. This means that the starting points for improvement were already included in the As-Is analysis. This change in methodology led to more encouragement of the team members as they could already see in the As-Is analysis were changes and optimization should take place. In some cases the Should –Be structure was already developed.

This change in methodology made it easier to carry out the next step **“Development of concept”.** In this step the Should-Be situation has to be defined. As the process steps that were missing or not properly carried out are already included and marked “red” within the process charts, the staring point for the optimization is already defined. So the time and effort to define the Should-Be situation was reduced dramatically.

The experience of the case studies regarding the disadvantages of the classical business process reengineering methodology and the enlargement of the classical methodology by the value analysis and the ARIS methodology to overcome this shortcomings, led to a new methodology consisting of the following steps:

Prepare business process reengineering project: The first step is a definition of the strategy of FM and the goals of the project based on the general strategy of the company. This makes it possible to check the result of the project at the project end. This step has to be carried out together with the facility manager and the board of directors. In this step the teams and the process owners also have to be defined.

Communication of the necessary changes: The communication of the goals and area of changes has to be done by the board of directors. This step should give confidence to the middle management, trade union and the employees. As often change leads to fears about employment which leads to opposition to change.

Identification of the core process landscape[1]: The core FM processes have to be defined. Basis for the estimation are descriptions of the processes at a high level of abstraction. This step also includes the definition of more detailed goals for each process regarding time, cost and quality.

Analysis to understand processes and collect ideas for redesign and optimization: This steps uses workshops, interviews and observations. The internal team is quite often supported by external consultants, as they can bring in new ideas.

Development of concept: Based on the gathered knowledge and ideas a concept for the optimization of the FM processes is defined. This concept includes the process steps, the organisation and the ICT support. Outcome of this concept are the required changes in organisation (new organisation structure) and ICT (e.g. tools, ICT landscape, integration of tools).

Change management for organisation: According to the requirements of the concept the organisation has to be changed.

ICT implementation: According to the requirements of the concept the new ICT landscape must be implemented and integrated.

Coaching of process owner: The last step is the coaching and training of the process owner and his team, so that they are capable of taking over the new tasks and responsibilities.

The new step “**Prepare business process reengineering project”** makes sure that the strategy of the company as a whole and the strategy in respect of facilities is taken into account. The step

[1] Selection of the core processes was skipped, as it was found out that FM process landscape consists only of seven to ten processes and all of them were important for the success of FM. So all of them had to be taken into consideration.

“**Identification of the core process landscape”** assures that all relevant processes are defined. The step “**Development of concept”** identifies the necessary changes in organisation and ICT. Together with the steps “**Change management within organisation”** and “**ICT implementation**” a proper change management and implementation is granted.

7. Conclusions

This new methodology was already used in several case studies. It could be proofed, that by enlarging the classical business process reengineering methodology by the value analysis and the ARIS methodology, the disadvantages could be overcome. The new methodology proofed its usability and efficiency in the case studies carried out.

Nevertheless, the appliance is still very time consuming. Therefore, in the next step the research team wants to define reference process models for most of the “core” FM processes. These process models can be used as reference for the modelling of the processes within the companies, which will reduce the efforts in time and cost.

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Quality Assurance in the Facility Management for Public Real Estate

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Abstract

In order to reduce the burden of an efficient and effective direct management of the real estate, Public Organizations often delegate the management of their heritage to Private Organizations. A whole control of management activities and the assessment of quality represent the first request expressed by the Public purchaser.

The present paper points out methods and tools to control the management procedures of the public building heritage entrusted to Private Organizations. The work establishes parameters that affect the building's quality and the conditions in which the information examination and exchange among operators is to be carried out.

The control activity requires a continuous monitoring of management procedures, that can be performed only by an adequate informative system focused on the basis of the specific characteristics of the real estate and of the contractual agreements. The system should guarantee a continuous exchange of information between the owner and the Management Organization, in order to reach the quality control of the facilities management, and to convey the needs of the purchaser, determined by its political, social and economic strategies. Moreover, in each step of the management process, the Public Organization should have the access to specific information, as the following:

- building and plant data;
- maintenance plan and procedures of intervention;
- working progress and shifting by timing plan;
- resources in relation with the available budget.

These data should be periodically controlled by the purchaser in order to verify the quality of the management activity and give the Management Organization corrections to optimize the facility management. The continuous update and aggregation of information through the informative system and the control of each step and procedure done by the Public Organization, allow a timely action in case of disorders and not-performance of the contract.

The research purpose is to create a methodology for quality management to reduce the risk of mistakes in the steps of analysis, inspection and intervention, singling out the responsibilities of the maintenance managers and verifying the respect of procedures and activities included in the contract. The plan is focused on meaningful parameters to control the performance levels that should be guaranteed by the Management Organization, in terms of:

- reliability of the buildings' information;
- effectiveness of the diagnosis;
- ability to forecast;
- timeliness of intervention;
- optimization of the cost;
- satisfaction of the users.

Keywords: quality, facility management, public real estate, informative system, control.

1. Introduction

The singling out of strategies and procedures aimed to recover, maintain and exploit the public heritage is one of the main objectives in order to optimize the built resources. The Public Administration development policies should direct the planning of maintenance for the public real estate. The knowledge of these policies allows the optimization of investments in relation with the performance levels required. In fact, the result of an effective and efficient management of the public real estate enhances the whole area, having positive repercussion on the private heritage too [3].

Nevertheless the Public Organizations owner of big real estates often entrust private companies to manage their property. This choice is due to shortage of their staff and liquid assets, lack of competence in building maintenance, complexity of the management procedures of contracts and financing [1]. In fact, in order to optimize the public resources, today the Public Administrations rely on themselves only for their core business, such as the activities that have to satisfy the needs of citizens. Therefore, for the technical services, as for the larger part of their accessory activities, they usually entrust private companies. Nevertheless, the Public Organization should continue to control the activities performed by the Manager Organization, verifying the information reliability, their updating, the correct use of the collected data in inspections, diagnosis and intervention steps. This information allows the purchaser to control the conservation condition of its real estate and its value in time, in order to single out and assign the maintenance financial resources.

The present study's aim is to supply the Public Organizations owners of building heritage with a methodology and tools to control the management of their real estate. Today, the Public Organizations need effective tools to control the quality of the facility management, in order to verify the respect of contractual agreements, the coherence with the strategic policies planned by the purchaser, the conservation and exploitation level of the real estate.

The facility management is characterized by different activities and services, constantly performed in time, that require a managerial approach, involving different competencies. The Manager Companies should be flexible and dynamic, adjusting their organization to the specific need at the specific time.

In Italy, in the last ten years many companies involved in management of big real estates have been formed [8]. They can provide technical, legal and administrative services. Nevertheless the Public and Private Organizations that have entrusted their real estates to Private Manager Companies did not concretely benefit of their action, neither in maintenance nor in exploitation of the heritage, or in optimization of the financial resources available.

The ineffectiveness and the inefficiency of the management activities, in the case of facility management contracts, depend on many factors, mainly in building maintenance. In fact, the quality of the results is related to variables that can be found in each step of the management process, starting from the interventions programming to its carrying out.

In order to increase the management quality, the purchaser organization should perform control activities along the whole process, requiring corrective measures timely. But the Public Administrations are not ready to carry on this role yet; in fact, in the facility management contracts, they delegate not only the maintenance intervention, but the whole management activities, including the survey of the technological efficiency of the buildings, their maintenance need and planning of management actions. Meanwhile, the purchasers are not able to control the management results, both in terms of comparison of costs and benefits, and in terms of quality of granted services. The Public Organizations sometimes evaluate the tenders made for the contracts, taking into account the proposed methods and tools to control the services quality: this means that the Private Organization suggests itself how to control its own job! In other circumstances, the control consists in formal checks: delivery reports on fixed days, completeness of reports on the activities advancement, delivery of cost control reports and certificates.

The complexity of managing a big real estate is mainly due to its heterogeneity: public heritage usually includes buildings of different ages and with various uses. The age is strictly related to the buildings' features (typology, materials, construction techniques, finishing, etc.), that affect the choices of maintenance intervention. The use determines requirements that should be satisfied by the building: the minimum performance levels that must be guaranteed change in relation with the users' needs. Durability of technical elements is affected at the same time, by materials, construction techniques and use. Therefore, the frequency of check, inspections and maintenance interventions are related with buildings' features and use.

Durability is also due to the materials and intervention techniques employed in building construction and maintenance. Public real estates usually include stone or brick-wall, reinforced concrete, steel, mixed structure, etc., with different types of technical elements and plants. This variety in building typologies, requires a careful control on the analysis methods, the frequency of inspections, the choice of intervention performed by the Manager Organization, that should be adequate to each case [7].

2. The Control Activity in the Steps of Maintenance Management*

The management of public buildings requires a thoroughly organized census and analysis. The absence of these has often conduced to an insufficient knowledge of the building, to the use of ineffectual technical and financial policies.

The process of census starts with the individuation of the building. The following steps are the knowledge of building, its coding and classification, and the evaluation of the building. The lack of knowledge of the real value of public properties and their temporal deterioration does not permit the setting up of a good maintenance policy, and does not allow adequate financing of extra-maintenance and investing.

In fact, the maintenance policies are often founded on urgency, based on rapid evaluations and lack of objectiveness. The maintenance management of public buildings is often founded on innovative ways, like Global Service. Unfortunately, in Italy the step of census is frequently skipped or it depends on the Global Services' bidder [4].

The Global Service contracts usually settles that the quality of the management activities have to be controlled on the basis of minimum performance levels, that should be previously fixed. These levels should be established not only on the basis of the buildings use, the laws and the technical standards, but also on the ground of economic parameters, defined according with the purchaser's strategies and the users' needs. In fact, the programming of maintenance should be founded on a clear expression of the purchaser's aims: the lack of a briefing activity affects the effectiveness and the efficiency of maintenance.

Often the Public Organizations decide the priority of intervention on the basis of political strategies, not considering available funds and effective needs. They are unable to establish building policies compatible to all. This because there is no definition of roles among political and administrative bodies, and most political bodies do not program further ahead than their predicted term.

Another problem is the internal conflict within the Public Organization itself. There is a lack of connection among different sectors, such as management, financial services, technical services, acquisition or sale of buildings, and urban planning. This is due to a lack of skills in the management of buildings, which can be explained through the following considerations: the introduction of managerial logic requires gradual innovation and skills diffusion; the management policy is static; the management policy is often considered an exclusively political issue, that does not require a technical support; the organization does not allow relationships among its internal units.

Some Public Organizations tried to solve the problem of lack of knowledge of their buildings through an initial step of census (individuation of the building; knowledge of building; coding and classification of the building; evaluation of building). Nevertheless, many Public Organizations that undertake the Global Service, have a lack of adequate legal, administrative, physical and functional knowledge of the buildings, so that the object of the contract and the costs are often not well established. In the end, the control of the quality assurance and of the offered services is difficult for the Public Organization for this lack of knowledge.

The control activities that the purchaser should perform in maintenance management can be summarized as follows:

STEP 1 - Building knowledge

In this step the quality control should be focused on the following parameters:

- completeness of information on the building's technical elements;
- adequacy of survey methods, evaluated on the basis of the needed detail degree, of the available financial resources, on the skill of the operators involved in the survey, on the available equipment, on the accessibility condition of the building and its parts.

The building information should be surveyed using check-lists, in order to guarantee the comparability of data and to easy up and quicken the operators' activity.

STEP 2 - Planning of inspections

The inspection methods and frequency should be adequate to the building's construction features. For big and heterogeneous real estates, it is necessary to plan inspections on the basis of the information surveyed in each building. Durability of the materials and technical elements, building localization and use are the parameters that should be controlled to program the inspections.

In order to guarantee the quality in inspections we should control the following parameters:

- required operators' skills in inspection activities and necessary equipment;
- environmental conditions of each building (air pollution, traffic, acid rains, etc.) that influence the scheduling of inspections;
- accidental factors, that can speed up the degradation process or produce damages, requiring unforeseen inspections or interventions;
- accessibility condition of the building and its parts, that affect the completeness of information.

The prevision capability is founded on an effective and efficient inspection plan and on reliable diagnoses. The quality control in inspection activities allows the Manager Organization to optimize maintenance, reducing, in time, the controls frequency and the interventions extent.

STEP 3 - Diagnosis

The results of the diagnostic activities depend both on the accuracy and completeness of the surveyed data, and on the professional skills of the operators involved in data management. A correct diagnosis can ameliorate the maintenance, guaranteeing timely interventions and increasing building's life cycle. Often the relationships between degradation causes and degradation phenomena is not easily comprehensible. This because many causes can be related to a single degradation/damage phenomenon or the decay can be the result of a chain process.

In the diagnostic step, the quality control should be focused on the following parameters:

- reliability of the relationships between causes and degradation phenomena;
- accuracy of the analysis of degradation evolution;
- survey of the effects of damages and decay of each technical element on the whole building system.

STEP 4 - Intervention

The information system for maintenance management should describe the interventions needed to improve the technical elements' performances, showing the intervention's frequency and length, the operators, the equipment and the required materials. The information system should also show risks or troubles for the users involved in the maintenance intervention.

The quality control should be performed on the following parameters:

- congruency between the frequency of intervention and the information on materials and technical elements' durability;
- timeliness in the diffusion of diagnostic information, in order to quickly activate the intervention;
- adequacy of intervention techniques, in connection with the materials and the construction techniques of each element, and with the building restraints and available resources;
- effectiveness and efficacy of the available equipment and their compatibility with the type of intervention to be performed.

It is also necessary to control the intervention results:

- efficacy of the intervention, on the basis of the achievement of performances required;
- skills of the operators involved in maintenance interventions;
- intervention timeliness and length;
- costs, due to materials, components, manpower employed and length of intervention.

The information surveyed for maintenance management is usually recorded in electronic databases provided with a data processing system, that uses periodically updated databases [2]. The information is collected at the beginning of the contract and by periodical inspections, and all the interventions are recorded. The computerized management allows the continuous control of the activities performed by the Manager Organization, if the purchaser can access to the informative system [5-6]. Therefore, the Public Organization should include in the contract the bond for the contractor to guarantee the access to its database within the time prescribed by the quality control prescriptions.

Many Public Organizations have increased the number of services included in the contract. In the Global Services are often included the program and the carrying out of ordinary and extraordinary maintenance interventions, the management of buildings knowledge, of rents, defaults, and evictions, doorman services, cleaning service, and electricity supplying. Therefore, a quality management is necessary to control the offered services. In planning the quality, the Public Organizations can analyze and establish the way for the execution of the contract.

The application of a Quality Plan to the Global Service contract allows to avoid the selection of not qualified companies, to guarantee adequate logistics, to clarify the management method proposed by the contractor, to establish sub-contracts, to evaluate professional skills and qualification of the contractor, to understand the work methods proposed by the contractor, to review the services plan, and to analyze the quality control plan of the Manager Organization.

It is necessary to introduce in the Italian Public Organization a new professional skill, the Process Manager, in order to manage and control the whole process, and to guarantee the respect of the contract.

A high ability in planning and control of the maintenance is required to the Public Organizations. In fact, this task can not be completely delegated to the contractors, because they can not manage the social policy, the financial strategy and the budget for investments in the public estate. This estate is unsteady, because it is conditioned by obsolescence, need of maintenance interventions, requiring continuous management and control of the choices.

3. Study - Case: the School Buildings' Management in the Province of Naples**

The Province of Naples, an Italian local Public Organization, manages about 300 school buildings. With an agreement signed in 2000, the Province entrusted the ASUB company for the management of the school buildings, in order to maintain the efficiency of its property. ASUB is a limited company in which the local public authority holds the majority of share and it performs preventive and damage ordinary maintenance. The extra-ordinary interventions are usually directed by the Province's Maintenance Office.

Today the Province has an office directly involved in maintenance of school buildings, organized in four units, each one responsible of about 75 schools, and an office that manages the relationships with the ASUB (Activities Direction Office for ASUB). This because the ASUB required a single referent in the Public Organization.

The contract with ASUB included the census of the real estate, the surveying of the maintenance status and the management of maintenance interventions. The surveying was created to allow an electronic management of information, starting from a detailed knowledge of the buildings.

The census card includes information about the building, assigning it an identification code. The date of drawing up as a time reference, and the name of the surveyor are also reported. In the first section of the census card is given general information about the building:

- localization (main entrance, secondary entrance, name of the school, Council, District);
- owner data (name, address, city, telephone number, type of building: the whole building, blocks of buildings, part of a building);
- land-registry data;

- quantitative data (building area, green area, waterproof area, maximum height, number of floors, number of underground floors, number of staircases, building volume, underground volume);
- presence of cavity under the building;
- accessibility (vehicular and pedestrian accessibility, street and pedestrian access width, traffic, near by adjacent buildings).

The second section of the card reports structural information, as follows:

- vertical structures (stone or brick-wall, reinforced concrete, steel, mixed structure, etc.);
- horizontal structures (vaults, mixed floors in reinforced concrete or steel and bricks, etc.);
- roofs (sloping roof, vault roof, flat roof, etc.);
- internal staircases (reinforced concrete, steel, brick-wall, etc.);
- emergency outdoor staircases (number, structure features).

In the third section of the census card the following information about the other elements of the building is reported:

- wall panes (tufa-wall, brick-wall, cavity brick wall, prefabricated panes, etc.);
- external wall-finishing (plaster and paint, ceramic tiles, glass-sheet façade, marble or stone plates, etc.).

Plants are described in the fourth part of the card, as follows:

- lighting (presence of lighting in common areas, automatic gates, electric plant of the doorman's lodge, earth plant, lightning-conductor plant, etc.);
- water plant (connection with the public sewage system, presence of pumping system, etc.);
- fire water plant (connection with the public system, autonomous water reservoir with motor-pump, portable fire-extinguishers, etc.);
- heating system (centralized system, type of fuel, presence of chimneys, etc.);
- other kind of plants (gas, air conditioning, intercom, video-intercom, elevators, lifts, etc.).

The card also reports all the plants certifications and the general conservation conditions of the building, with the judgement of the surveyor, on the basis of parameters described in the contract (very good, good, mediocre, poor, unusable).

The building information comes with drawings in vectorial format: plans, front views and sections fitted out with the use of each room, symbols and codes of the most part of the technical elements and the plant. These codes are reported in tables containing data on the location of each technical element (floor number and room), class of elements (floors, coatings, windows, electric plant, heating system, etc.), description of the element (ceramic tiles, washable paint, casement window in aluminum, plug, fan-coil, etc.), quantity or dimension (number, square meters, etc.) and judgement about conservation conditions or effectiveness.

The contract includes some programmed intervention, scheduled on the basis of buildings' materials and construction techniques or for the plants' features. The contract also establishes periodic inspections in the buildings in order to control the maintenance status (Figure 1).

Even if the buildings' information surveyed seems to be exhaustive, the purchaser does not control the updating. In fact, after the sample check performed by the Maintenance Office operators at the end of the census step, the systematical control on the information reliability is not performed. In fact, the information is not recorded in an informative system directly accessible both by the purchaser and the Manager Organization. Therefore, the Province can't control if the ASUB periodically updates the information.

The management contract includes an annual cost per square meter for ordinary maintenance, defined by the analysis of historical information and data by literature on maintenance costs. The total cost for each school is calculated adding 10% of the external areas to the internal surface of the building. The contract establishes that 70% of the interventions performed by ASUB are included in a fixed amount agreement and 30% are calculated on a measurement and payment base. The fixed amount is annually granted, and includes boundary and optional interventions.

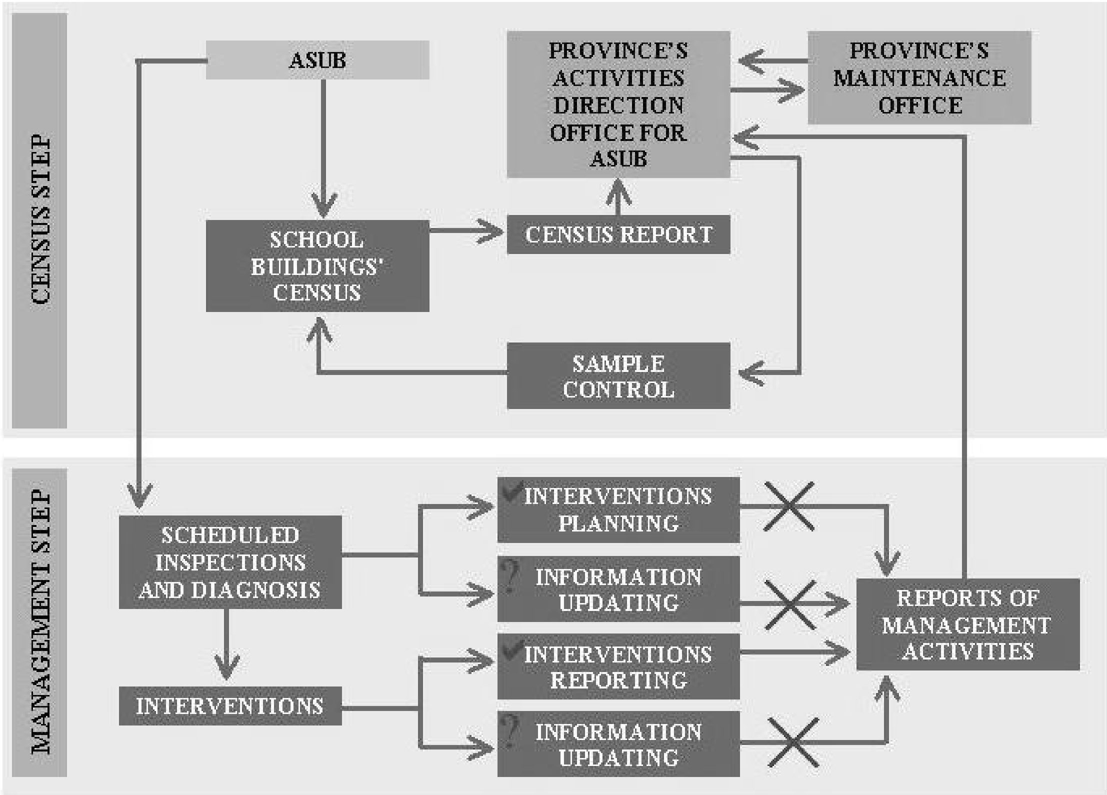

Figure 1: Information flow for the school building's knowledge in the Province of Naples

The ASUB sends to the Activities Direction Office for ASUB the reports of the intervention performed included in the fixed amount payment (Figure 2). In spite of the fact that financial penalties are established if the Manager Organization does not perform the interventions required, the control of the optional interventions is not systematically performed. The extra-ordinary maintenance and the ordinary intervention not reported in the contract are computed by measure. The accountancy reports and the intervention performed by ASUB are controlled by the Activities Direction Office for ASUB. This office can't control in situ each ordinary intervention performed. The Province's Maintenance Office also does sample controls.

The main problem of this management system is the control on the information flow: the need of intervention can be foreseen, can be surveyed in the inspection activities or can be required by the users if a damage occurs.

The users' request of intervention can be addressed both to the ASUB or to the Province's Maintenance Office. This office asks the Activities Direction Office for ASUB to report the request to ASUB, but it does not receive the information about the results of inspection or intervention.

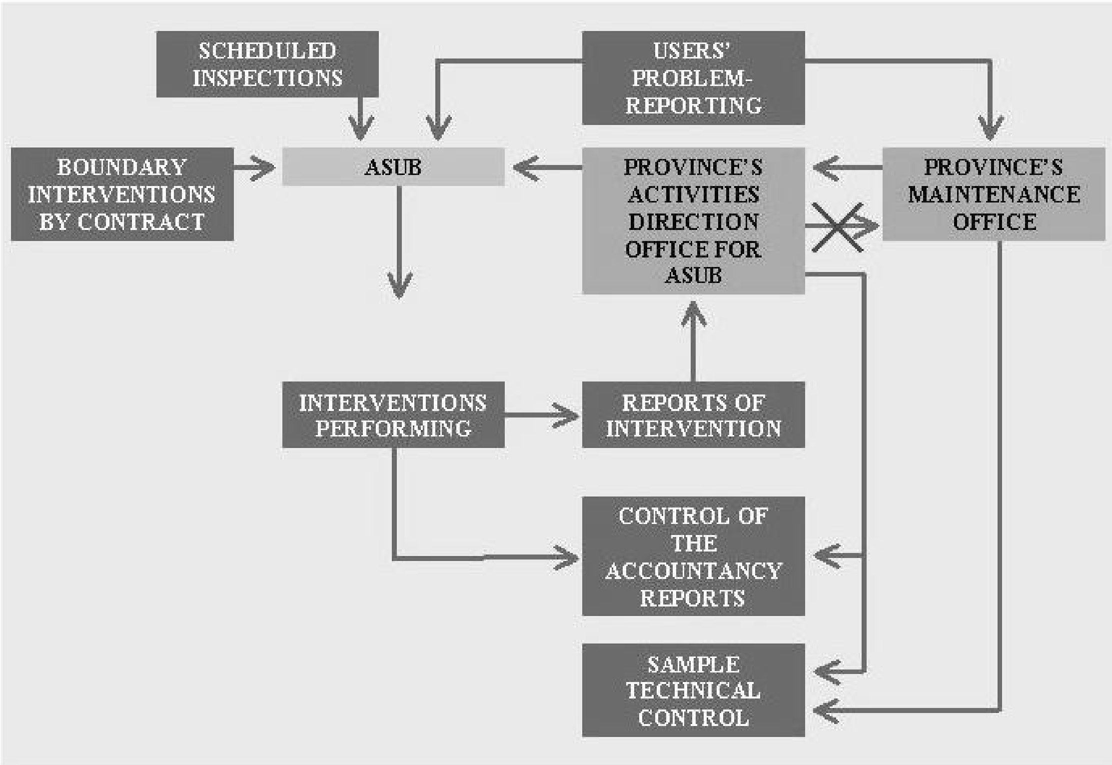

Figure 2: Information flow for the school building's ordinary maintenance in the Province of Naples: the Province's organization produces confusion in duty.

4. Conclusions

The quality control in management of real estates is a strategic activity that can guarantee the economical value conservation and the enhancement of the public building heritage. The purchaser, entrusting Private Organizations management activities, should maintain a strategic role in planning and control. It should define the maintenance policy on the basis of both the surveying of users' needs, and the available funds.

The control should be performed on specific indicators:

1. Building analysis and diagnosis:
- Buildings knowledge: adequate information about materials and construction techniques (STEP 1).
- Functionality definition of the technical element: definition of the function that each element should perform (STEP 1).

- Conservation condition evaluated on the basis of effective degradation and damages: type and intensity of the surveyed phenomena in order to guarantee a reliable control and to increase the quality of information for the maintainers (STEP 2 – 3).

2. Forecast capability:
   The systematization of the information surveyed in the periodic inspections allows the optimization of the available resources, reducing, in time, the number of inspections and the extent (and the cost) of the interventions. The forecast capability is related to an effective inspection plan and to correct diagnoses of building degradation and damages (STEP 2 – 3 – 4).

3. Timeliness in intervention:
   The definition of intervention priorities should be founded on different criteria, on the basis of the maintenance strategy adopted. In damages maintenance the purchaser should evaluate the time past between the knowledge of the damage and the execution of the intervention. In planned maintenance the respect of scheduled activities and the forecast capability (STEP 4).

4. Intervention costs:
   The purchaser can previously establish costs on the basis of the kind of interventions, to fasten the accountancy reports and to foresee the total amount. But these fixed costs should be based on materials, construction characteristics, degradation and damages surveyed, and use of the buildings (STEP 4).

5. Users' satisfaction:
   This indicator can be evaluated on the basis of the timeliness in interventions and of their effectiveness. In the Global Service contracts, the Manager Organization usually receive the users' requests of intervention.

Starting from the aforementioned indicators, the Public Organizations can directly control the information of the activities performed by the Private Organizations entrusted in building management. These should report to the purchaser clear, complete and measurable information. The information should be compared with the results of the controls performed in situ, in order to verify its reliability.

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Performance Measurement Applications in Facilities Management: An Investigation into the Future Directions

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Abstract

Facilities Management (FM) is very frequently described as, "an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organisation in order to create an environment that strongly supports the primary objectives of that organisation". The practical and strategic relevance of FM to organisations in all sectors of the economy is now increasingly recognised. Accordingly, organisations seek to improve their competitiveness by introducing a core business philosophy and restructuring to release senior management time and improve effectiveness. Managements have begun to realise that for organisations to benefit from their enormous investment in facilities, they have to begin managing them actively and creatively with commitment and a broader vision. Formulation of techniques that are capable of assessing "facilities performance" in terms of quality, cost and effectiveness, is therefore critical for "Organisational" and "FM" advancements. Research has emphasised that there is a clear need to measure FM performance which would integrate both the business and facilities domains. Accordingly, this paper summarises a literature review of current leading-edge performance measurement and management practices within facilities management organisations and conceptual models of performance measurement and management from other industries. Accordingly, the paper identifies the directions to develop performance measurement systems in FM with specific links to measure facilities relationships with those of the core business.

Keywords: Facilities management, performance measurement, core business

1. FM and its importance in todays' business environments

Facilities management (FM) has traditionally been seen as simply the management of buildings and building services. FM is a key managerial discipline and large corporations are increasingly recognising its importance in respect of achieving organisational goals and objectives.

A variety of definitions of facilities management have arisen:

- “An intergraded approach to maintaining, improving and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of that organisaiton” [1];
- “The process by which an organisaiton ensures that its buildings, systems and service support core operations and processes as well as contribute to achieving its strategic objectives in changing conditions” [2];
- “The integration of multi-disciplinary activities within the built environment and the management of their impact upon people and the workplace” [3];
- “A process by which an organisaiton plans, delivers and sustains excellent support services in a quality environment to meet caning strategic business objectives at best cost” [4]

A number of basic issues may be derived from these definitions:

- FM is a function containing a series of linked activities demanding a requirement to co-ordinate all activities pertaining to the planning, design, and management of an organisation’s physical resources;
- FM is responsible for co-ordinating planning processes and managing a building’s continuing development and changing use patterns, as well as for maintaining the building
- The goal of FM is to contribute to organisation effectiveness by helping the organisation to allocate its physical resources in a way that allows it to flourish in competitive and dynamic markets.

<u>but</u> as shall be seen in due course:

- FM is not just about the maintenance and operation of buildings although so much of its activities are building-related. More accurately it is about the management of a range of services, of a variety of forms, which are necessary to support the primary activities of an organisation;
- These services are invariably people intensive which means that human resource management issues and the so-called “soft” issues are highly significant; and
- FM has no raison-d’etre or justification of its own - it only exists as a means to support the primary, goal-seeking, activities of the organisation. Nevertheless the potential impact of the efficacy of FM upon organisational success may be highly significant.

FM is intrinsically bound up with creating the conditions in which business effectiveness may be achieved. All decisions taken about FM are business decisions albeit subject to technical or organisational criteria. The business case for developing and applying the discipline of FM depends upon an understanding of the potential the approach holds for creating quality working environments to support key corporate activities. Effectively planned facilities and quality support services can generate significant business or organisational returns.

The conditions within which facilities are operated and developed, and therefore the contribution they can make to the organisation, need to be set at the most senior level in an organisation. Strategic business decisions about responses to market conditions, competitive pressures, statutory obligations, and organisational restructuring are all business decisions which will have direct facilities implications. Company policies for production, marketing, human resource management, and finance each have profound significance for the manner in which facilities management services will be required to be delivered. In this context, following section highlights strategic role of FM.

2. Strategic Role of Facilities Management

FM has three facets in organisations: sponsorship, intelligence, and service management, according to Williams and Roberts (2000) [5]. CFM (2002) [4] identifies sponsorship FM role as the “translation” role with a strategic focus:

- Get the chief executive officer and senior management involved in the process and make them are of the possible outcomes;
- Strategy involves a change management process, which will have an impact on the built environment and the human resources;
- The focus of the strategy is the community, not the building or property, or a project;
- Every individual in the company (from top management to staff) see the project as a business project, which has an impact on the business objectives

Nevertheless it is true that many organisations remain blind or indifferent to the strategic potential of FM to stimulate strategic change or competitive advantage. Instead of being seen as a strategic tool the built assets and human resources and systems remain defined as an obligation or liability, that is as unavoidable costs and charges, cost centres rather than profit centres.

FM and the business or organisational sector may be able to reach a better understanding of each others needs and potential by the co-ordination of decision-making which demands a facilities input, and which would help to bridge the gap between primary business and support activities, i.e. core and non-core. There is a powerful need for a generalised set of principles for the contribution of FM to the defining of business problems, the analysis of options, and the strategic choice of solutions. The discipline itself needs to adopt a more strategic posture about its future path, by protecting and developing the distinctiveness of its range of management activities and mix of managerial and technical skills, thereby confirming its relevance to the whole business process.

This leads to another role, which FM is playing increasingly in performance measurement (PM). The need to monitor, assess and measure FM performance to enhance workplace productivity has become critical, particularly from the strategic point of view of FM.

3. Role of performance measurement within business environments

PM is mostly identified as a system which enhances individual performance to support or achieve the organisational goals [6]. As continuous improvement in a business cannot be gained without measurement of its performance [7], measurement of performance has been given a prominent place in any organization. Kagioglou *et al.,* (2001) [8] defines, the PM as “the process of determining how successful organization or individuals have been in attaining their objectives and strategies”. Since PM systems encompasses supporting infrastructure a more wider definition has been given by Nelly (1998) [9] as the quantification of efficiency and effectiveness of past actions by means of data acquiring, collection, sorting, analysing, interpreting and disseminating. Cain (2004) [10] identifies PM as the first stage to any improvement process that benefits the end users with lower prices, and the organizations with higher profit margins whilst enhancing the quality of the product. Thus, it can be said that PM is an important aspect for any organization to evaluate its actual objectives against the predefined goals and to make sure that the organization is doing well in the competitive environment. Love and Holt (2000) [11] summarise the importance of PM as it: Ensure that customer requirements have been met (and if not, why); Enable establishment of achievable business objectives and monitors compliance thereto; Provide standards for business comparisons; Provide transparency and scoreboard for individuals to monitor their own performance; Identify quality problems and those requiring priority attention; Give and indication of the costs of poor quality; Justify the use resources; and Provide feedback for driving the improvement effort.

This section has highlighted the importance of PM in business environments. In this context, the following section identifies its role within Facilities environments.

4. Critical role of performance measurement systems within facilities environments

The importance of PM in FM organisations are been well documented in the literature. Alexander (1996) [12] identifies measurement of performance as one of “three essential issues for the effective implementation of a facilities strategy”. Due to the increased complexity of FM organisations facilities managers are accountable for the senior management regarding the FM contribution to business results and for the economic health of the organisation, the senior management at the core of the business will want to know the performance of facilities. In addition, the contributions made by the FM organisation would be assessed by the stakeholders of the organisation. Thus, facilities managers are under pressure to improve the performance in FM organisations to justify their success to the management as well as to the stakeholders. In this regard PM can play a major role in FM organisations by providing periodic information about the attainment of goals and objectives in the organisation and can guide the management towards new directions to enhance the facilities within the organisation.

Amaratunga and Baldry (2002) [13] identify the ways in which FM could contribute to the performance of an organisation such as strategy, culture, control of resources, service delivery, supply chain management and, management of change. Spedding and Holmes (1994) [14] state that FM should not only focus on reducing the running cost of the building, but also should consider the effective and cost efficient ways of space management and achievement of organisational goals. Therefore, to identify the effectiveness of the contributions of FM functions, performance has to be measured. Thus, PM systems play a critical role in this aspect.

Facilities managers are increasingly valued for their entrepreneurial skills and knowledge of the core organisation, with the ability to pre-empt and translate the organisation's need for change into facilities strategies which underpin operational objectives to yield competitive advantage. Further more, strategic appreciation and development has been viewed as the corner stones of any facility management strategy. Thus, it can be argued that PM applications within FM organisations can assist the facilities managers toward achieving the strategies in the changing business environment.

The concept of providing one working space for all the employee activities of the organisation has been changed and the concept of "activity settings" which looks at different work settings ranging from open plan, meeting spaces, quiet concentration areas, conference rooms etc. has been emerged. Thus, corporate office space planning has become an important characteristic of FM organisations and the efficient and effective management of office environment has challenged facilities managers [15]. He argues that the old adage "you can't manage what you can't measure" fit the corporate infrastructure well. Thus, PM can play an important role in FM organisations by providing quantitative and qualitative data in terms of the effective use of the building space.

The above context shows the important role played by PM in FM organisations in way of providing valuable information regarding the attainment of aims and objectives of FM organisations. In this context, following section identifies current, leading edge, PM practises within FM organisations.

5. Current performance measurement and management practices within facilities management organisations

The importance of assessing performance in FM and a general need for the assessment of FM were discussed in the above section. In recent years, a number of management tools have been found to be particularly useful in the area of FM evaluations. The provision of information decision-making is a key component of a facilities strategy, in particular literature emphasises the usefulness of facilities performance measurement techniques.

The tendency of using the PM frameworks instead of the traditional measures can be identified in the PM applications in FM. For instance, the application of Balance Scorecard [16]. Further, the development of frameworks (Service Balanced Scorecard) based on the fundamental principles of Kaplan and Norton's Balanced Scorecard can be found which appraises the performance of property organisation's against their the strategic aims [17].

Process based approach to evaluate the performance in FM organisations can be found in the current FM literature [18]. This identifies the importance of process thinking in FM organisations as it would help to align the activities of the team members towards a common goal. They argue that even though the FM has been defined in many ways, most of these definitions identify the core competencies of FM as understanding business organisation, managing people, managing premises, managing services, managing the working environment and managing resources and recognise FM as a business process. One of such approaches is the application of the SPICE (Structured process improvement for construction environments) model.

Further, a survey as reported in Amaratunga & Baldry (2002) [19] as presented in

Table *1* presents a picture of PM practices within FM organisations. This random sample may have produced a lower proportion of respondent employing the measurement techniques.

Table 1: Use of approaches/techniques for the measurement of FM performance

Approach for the measurement of FM performance	***Number using the approach***	***Proportion against the total sample***
- Business excellence model (EFQM)	3	20.00%
- Best practice Benchmarking	5	33.30%
- Total quality management	1	6.67%
- Customer satisfaction surveys	10	66.67%
- Post-occupancy evaluation	6	40.00%
- Evaluate return on funds employed	-	-
- Through observe of complains	7	46.67%
- Employee indexes	-	-
- Measurement against service level agreement	1	6.67%
- No method used	1	6.67%
- Any other method	-	-

The use of a broad range of approaches to the measurement of performance in FM was confirmed by the survey and the interviews carried out. It was further confirmed that appraisal techniques for assessing performance should become an essential part of the FM process, particularly those that provide information that can be arrayed so as to ensure management can learn about the consequences of their actions.

There is frequent comment that there are too many performance indices (especially in terms of cost) in the FM market. Therefore, a more positive and preferable stance in respect of performance measurement in FM is needed and the evaluation process should stand up to scrutiny and allow the measurement of FM performance of individual services as well as aggregating this information into indices and integrated performance measurement “universes”. This should allow assessment of FM performance covering various perspectives of FM together with FM’s relationship to the core organisation, although to date the key problems have been those of performance measurement techniques’ availability. This leads to the exploration of similar applications within other industries from whom, FM can learn lessons forms. In this context, the following section highlights some of the most common PM approaches available within other industries.

6. A literature review of conceptual models of performance measurement and management from other industries

In order to overcome the problems associated with the traditional measures such as encouraging short-termism [20], [21]; inability to provide stakeholder perspective [22], [23]; lack of focus on the strategy [21] etc., and to facilitate the effective and efficient PM in the current business environment, various integrated and multi-dimensional PM systems have been developed.

The newly developed integrated performance frameworks have attempted to tie the performance metrics more closely with the firm’s strategy and the long term vision [23]. This is due to the recognition of the importance of deriving the performance measures from organisation’s strategy [24], [25], [26]. Further, it was argued that there is a need to align the financial and non- financial measures that fit within a strategic framework [27] and [28] where the non-financial measures reflect the organisational objectives while the financial measures indicate the bottom line results [29]. In addition the need of PM systems to provide a balanced overview was highlighted by many authors [30] and [31]. Accordingly, the following section discusses the common PM frameworks used in other industries.

The importance of deriving the performance measures from the strategy of the organisation has been recognised widely [24], [25], & [26] thus the newly developed integrated performance frameworks have attempted to tie the performance metrics more closely with the firm’s strategy and long term vision [23].

7. Supply chain performance

Over the past two decades, manufacturing industry has changed in to a highly competitive field due to the emerge of foreign and local competitors. Due to this competitiveness many firms are adopting different strategies to secure their market share. One of such is merging with suppliers by forming long term strategic partnerships which is known as supply chain. Supply chain has been defined as ‘a system whose constituent parts include material suppliers, production facilities, distribution services, and customers linked together via the feed forward flow of materials and the feedback flow of information’ [32]. Several models have been developed [33] & [34] to measure the performance in manufacturing supply chain.

7.1 Evaluating managers’ performance

Another strategy developed in the manufacturing industry is to build up the flexibility of the firms [35] to meet the goals of the organisation in a more dynamic manner. A study has been done in this area [36] by evaluating managers’ performance through manufacturing flexibility measures.

7.2 Measuring the long term performance

Measuring the long term performance in manufacturing industry is another approach used [37]. Performance metrics such as advanced manufacturing technology usage, advanced management practices usage, globalization and cooperation capacity and the match between manufacturing capabilities and market requirements are considered to ascertain the long term performance.

7.3 Service Balance Scorecard

Traditionally the performance in Local Government Authority’s are measured using financial measures such as occupancy cost to m2, full-time employees, lease cost, lease income, capital expenditure, total revenue etc. Service Balance Scorecard (SBS) has been developed to eliminate the problems associate with the aforementioned traditional measures and a study has been done in this area [17]. The SBS provides a new method to evaluate facilities linked to a Local Government Authority’s by measuring the performance in terms of Financial perspective, Building perspective (how well the facility is used in terms of time), Services perspective (how well the facility delivers, services to the community in line with the Local Government Authority’s objectives) and Community/customer perspective.

7.4 Satisfying the customer expectations

Even though the supply chain performances are traditionally focused on operational logistic activities, the trend has moved towards satisfying the customer expectations [38]. This has driven the performance measurement towards strategic measures [39]. Research has been carried out to evaluate the supply chain performance using process capabilities, technology capabilities and organisation capabilities from operational and strategic point of view [38].

7.5 EFQM model

EFQM model is developed on the principle that “Excellent results with respect to Performance, Customers, People and Society are achieved through Leadership driving Policy and Strategy, that is delivered through People, Partnerships and Resources and Processes” [40]. The model consists of five “Enablers” namely leadership, people management, policy and strategy, resources, processes, and four “Results” called people satisfaction, customer satisfaction, impact on society and business results. The enabler criteria concerned with how the organisation undertakes key activities while the results criteria are concerned with what results are being achieved. A logic called RADAR lies at the heart of the EFQM model consists of Results, Approach, Deployment, Assessment and Review. Thus, when using the model with an organisation, the Approach, Deployment, Assessment, and Review elements of the RADAR logic should be addressed for each Enabler sub-criterion and the Results element should be addressed for each Results sub-criterion.

The model has a non-prescriptive approach and can be used to carry out excellent quality management and self-assessment of the organisation. The organisation can use the model to develop their vision and goals for the future in a tangible and measurable way, help to identify and understand the nature of the business, identify the cause and effect relationships, use as a diagnosis tool for assessing the current status of the organisation [40].

7.6 Performance Prism

Performance prism consists of five interrelated aspects: Stakeholder satisfaction; Strategy; Processes; Capabilities; and Stakeholder contribution. Similarly to the BSC, the performance prism looks at the needs of stakeholders, but in a broader way. Further, performance prism does not limit by addressing the needs of shareholders and customers as in the case of BSC, but goes beyond that and addresses the needs of employees, suppliers, intermediaries, regulators, community as they too have a substantial impact on the project performance [41].

In most of the PM frameworks, the measures are derived from the strategy, but in the performance prism it is the other way around. The strategic, process and capability aspects of the performance prism have been derived by considering the requirements that is needed for the stakeholder satisfaction which is different from the general approaches of the PM frame works. Furthermore, performance prism identifies the reciprocal relationship between the stakeholders and the organisation. Therefore, focusing on the stakeholder contribution can be identified as a unique feature of the performance prism [42].

7.6 Other mostly cited models

In addition to the above PM frameworks, SMART (Strategic Measurement and Reporting Technique) developed by Wang Laboratories [43] which includes the internal and external performance measures, Keegan et al's (1989) [44] performance metrics based on the combination of cost and non cost measures can be identified. The Macro Process Model, developed by Brown (1996) [45] is based on the concept of cause and effect relationship of the organisation which shows the links between five stages of a business process (inputs, processing systems, outputs, outcomes and goals), and the performance measures.

The PM models used by other industries were reviewed in the above section. It can be identified that every model has its own set of advantages and disadvantages and the suitability of a model to a particular scenario is governed by these advantages and disadvantages.

8. Directions to develop performance measurement systems with specific links to measure facilities relationships with those of the core business

As discussed in section 4, PM plays a critical role by providing concrete evidence about the successful attainment of organisational goals and objectives in FM organisations. A criticism levelled at FM researchers is that they do not use the concepts of PM in as rigorous a manner as, for example, business performance theorists. Furthermore, they make no use of more general discussions of performance measures, e.g. the usefulness of constructing a PM framework for FM, and add PM into models of FM processes in the same way that they add project management techniques. The study of PM in a FM setting has therefore been somewhat superficial. However, it was identified in from the section 5 the positive motive of PM applications in the FM organisations.

The commitment from the people factor involved in FM organisations has a major role to play. For instance, evaluation of the efficiency and effectiveness of the existing building in terms of user satisfaction, identifying new improvements to buildings etc. are major roles of facilities managers. Therefore, similar to industries like construction, "people factor" can be considered as one of the important assets of FM organisations as improvements and challenges in the FM organisations can be met through the work force. The importance of human resource performance evaluation systems to organisations in general [46] & [47] has been highlighted by many human resource researchers. Further the need of aligning the human resource management applications of the firm with other management activities, creating a positive relationship between the organisational performance and the human resource practices focused on employee commitment are being well accepted in the studies done in other disciplines [48]. Therefore, such directions can be taken by FM organisations by measuring the performance of its workforce.

Quality of designs has been identified as an important dimension of buildings [25], [49], & [50]. However, due to the emphasis made by various authors [51[& [52], a new culture has been embarked in the UK construction industry towards measuring the performance [53] and more emphasis has been focused on the performance of the physical process [54] neglecting PM during the design stage. Lack of attention towards the PM during the design stage of buildings may forego the efficient and effective use of space within the building. Thus, measuring the performance during the design stage of FM organisations can be taken as a new direction.

The industries like manufacturing has identified the importance of creating long term strategic partnerships with both upstream and down stream partners such as suppliers, customers, and logistics service providers and the need of integrating and managing the multiple processes within and beyond the boundaries of individual organisations in the supply chain [55]. The research done in other industries revealed that the PM in supply chain facilitates the inter-understanding and integration between the supply chain members and the results indicates the effects of strategies and potential opportunities [56]. Furthermore, aligning the performance measures with the corporate strategy of the organisation have been well experienced by the PM studies in supply chain management in other disciplines as it would make sure that the supply chain processes are delivering the value to the customers and acting as a core competency of the organisation [39]. Further, PM of the whole supply chain and all of its entities has been identified as a strategic issue by many industries [57].

9. Conclusions

Appropriate measurement procedures can provide major benefits. When applying current measurement principles applicable to FM environments, several problems have to be faced: it is difficult to isolate FM's contribution to organisational performance from the other business activities because it is always the intertwined efforts that eventually result in outcomes in the market place; the problem of matching specific FM inputs and intermediate outputs with final outputs; a third major measurement problem is the time lag between FM efforts and their payoffs within an organisational setting; besides problems with the selection of performance metrics, there is also the problem of determining the right norms to compare with; and another issue, which is already mentioned in the previous section, is the acceptance of performance measurement in FM.

Therefore, it is argued in this research paper that performance measurement techniques available in general management literature haven't been fully transformed into FM literature, emphasising the research need in performance measurement in FM. The process should include links to the core business at a corporate level.

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Structured Process Improvements in Facilities Management Organisations: Best Practice Case Studies in the Retail Sector

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Abstract

Facilities management is a key managerial discipline and large corporations are increasingly recognising its importance in respect of achieving organisational goals and objectives. Enterprises are able to improve their performance by the more effective use of resources, the matching of appropriate support systems to business activities, and the application of assertive management by those best qualified and equipped to carry it out. However, FM organisations lack clear guidelines to direct their improvement efforts and to benchmark their performance against other organisations. The SPICE FM (Structured Process improvement in construction environments – facilities management) maturity framework was developed as a response to this requirement. SPICE FM draws a distinction between FM organisations that have 'mature' or well-established processes, and those where the processes are 'immature'. This paper briefly describes the characteristics of the SPICE FM Framework, followed by a review of the key findings from the case study undertaken.

Keywords: facilities management, SPICE, process capability assessment, performance

1. Process Thinking in FM

A process has several essential features, which Ould (1995) [1] lists as follows:

- A process involves activity. People or equipment do things.
- A process also generally involves more than one person or piece of equipment. A process is therefore about groups, and concerns collaborative activity.
- A process has a goal. It is intended to achieve something and to produce results.

A process determines the way we act and react. The activities and tasks we perform to achieve a certain goals form the "process" for achieving that goal. A disciplined process will result in ordered and consistent patterns of behaviour, whether by individuals or by groups of people. The process defines how we act or react, or it defines the activities needed to fulfil a certain task. We have a process for 'going to work', a process for 'defining service standards', and so on.

In this context, most FM organisations focus on the services they provide. In such a business culture, people are naturally inclined to emphasise issues that are tangible, visible or measurable. Many organisations are likely to resist process improvement activities that do not contribute to short-term tangible results. Consequently, FM managers often view process related work as low priority. In contrast, process-focused organisations consider tangible results in service delivery to be just one aspect of the business picture. For such organisations, how the service is delivered is equally important. The objective is that process thinking should be accepted and used consistently. The process is seen as a disciplined way of conducting business. In contrast to functional definitions, a process perspective in FM focuses on the tasks and activities that take place internally in the FM organisation. The emphasis is on how the work is done, rather than the functional responsibilities.

In this context, SPICE FM is primarily concerned with management FM processes. The underlying philosophy is that if management processes are well performed, they will have an impact on the performance of core processes. SPICE FM does not prescribe how organisations should perform core processes. Instead, it focuses on creating a management infrastructure that allows members of staff to perform core processes successfully.

2. SPICE frame work

The SPICE FM process maturity model promotes continuous process improvement based on many small, evolutionary steps. It provides a system for initiating and implementing continuous improvement. The model divides these evolutionary steps into five maturity levels, which lay the foundations for continuous process improvement. The maturity levels form a scale for measuring the capability of an FM provider's management processes. Each level of maturity is defined by a set of key processes. When an organisation is successfully applying each key process, it can stabilise an important part of the service delivery process and achieve the next level of maturity. The five levels also provide guidelines on how to prioritise efforts at process improvement. Figure 1 illustrates the five stages of the SPICE FM framework. For each level, the model specifies a number of ‘key processes’. By following the steps in the model, an organisation can achieve effective and continuous improvement based on evolutionary steps. An organisation can only be at one level of the model at any one time. If an organisation is at level 1, but implements some of the key processes of level 3 or 4, it is still considered a level 1 organisation. This is because each level lays successive foundations for the next. An organisation has little to gain by addressing issues at a higher level if all the key processes at the current level have not been implemented. To date, the research has focused on defining the characteristics of Levels 1 and 2 of the model.

2.1 Stepwise improvements in organisational maturity

The process maturity model lays foundations for continuous process improvement, by establishing controls on service delivery *management processes* before focusing on technical issues. Starting with ad-hoc processes, the evolutionary 5-stage model guides FM organisations towards developing their process capability. In the SPICE FM framework, organisations at level 1 have little process focus. Organisations at level 2 have achieved high capability in managing service delivery. Level 3 focuses on knowledge management and sharing best practice across the organisation. In levels 4 and 5, the model introduces statistical controls and measurement. Level 1 of SPICE FM is the entry to the framework and has no key processes. Organisations at level 1 focus on achieving the seven key processes at level 2. This lays the foundation for the key processes at the next level. Each key process is defined by a set of critical practices that indicate if the process has been implemented in a way that is effective, repeatable and lasting.

Table 1 lists the key processes at level 2 and their "enablers". The SPICE FM approach is not prescriptive in terms of how activities are performed. Instead, the model focuses on the broader issue of process management. Effective process management encourages and supports innovative approaches to solving day-to-day business problems, rather than constraining organisations to a particular way of working.

Figure 1: The SPICE FM process maturity model

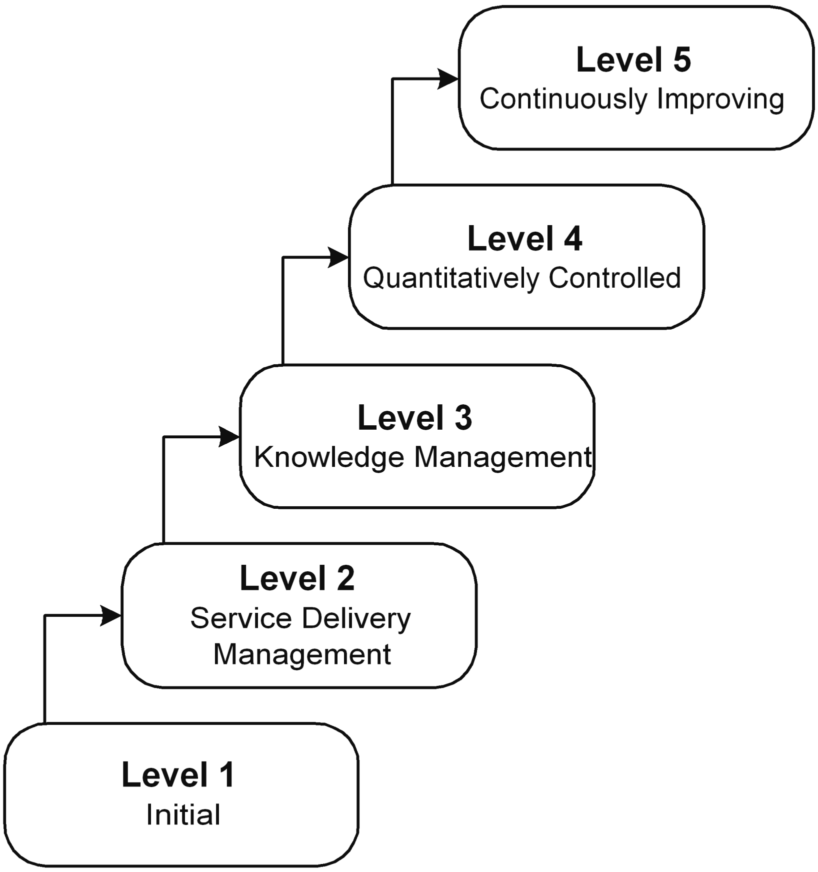


Table 1: Level 2 key processes and their enablers

Level	Key Process Areas	Generic Process Enablers
2 - Service Delivery Management	Service Requirement Mgt. Service Planning Service Performance Monitoring Supplier and Contractor Mgt. Health and Safety Management Risk Management Service Co-ordination	Commitment Ability Activities Evaluation Verification

2.2 Level 1 – Initial

Level 1 is the basic entry level to the model, and has no key processes. An FM provider at this level has little focus on process, and service performance is poor. Good practices are local, and are not repeated or 'institutionalised' across the organisation. The ineffective capture and co-ordination of service requirements tends to undermine good practices. Organisations make commitments that staff or the supply chain cannot meet, which results in crises. During a crisis, facilities managers typically abandon planned procedures; instead, individuals do whatever activities it takes to get the job done, with little regard for the effects on other people. Time, cost, quality and customer satisfaction may all suffer. Level 1 organisations must implement all of the level 2 key processes in order to progress, or 'mature', to the second level of the model.

2.3 Level 2 – Service Delivery Management

At this level, service performance can be predicted to a certain degree. A level 2 organisation has established policies and procedures for managing and delivering customer requirements. Service performance standards are established, and service delivery is co-ordinated to minimise disruption to the core business. As the service is being delivered, continuous monitoring ensures that performance standards are met. At level 2, FM providers have effective processes to directly meet the requirements of the core business. An effective process is one that is practised, enforced, trained, documented, evaluated and able to improve. To date, most of the efforts of the SPICE FM project have concentrated on defining and raising confidence at level 2 of the model. The research has identified seven key processes at level 2 which are described below.

- **Service requirement management** - Effective management of customer requirements identifies the needs of the organisation and its users. The service delivery team identifies how many tiers of customers it has and how their requirements differ. The team has a clear sense of priority in term of its customers and the service mixes it offers. Service level agreements and performance standards are developed and continuously reviewed to remain consistent with customer requirements. They are also communicated to all staff involved in service delivery.

- **Service planning -** Service planning establishes realistic schedules of work based on customer requirements. Estimates (e.g., resources, maintenance schedules, budgets, purchasing) are prepared for all work to be performed (e.g., scheduled and reactive maintenance).
- **Service performance monitoring -** Service performance monitoring ensures that services are delivered in a manner that is consistent with the service level agreements and performance standards established with the customer. Feedback is gathered (e.g., from customers and staff) to monitor customer satisfaction levels. Performance measures (e.g., waiting times, error rates, processing times) are reviewed on a regular basis, with the involvement of staff, and corrective action is taken when service delivery deviates significantly from service plans.
- **Supplier and contractor management -** This key process starts with the selection of suitable suppliers and contractors. Service level agreements and performance standards are established and their performance is continuously reviewed.
- **Health and safety management -** Health and Safety Management ensures that services are delivered in compliance with, or exceed, all mandatory health and safety legislation. Health and safety risks are identified, assessed, and action taken to eliminate or minimise the likelihood of any incidents.
- **Risk management -** Risk management involves identifying and evaluating risks so that action can be taken, either to reduce the likelihood of an event occurring or to limit the consequences should that event occur. Risks are identified in all areas of the business (e.g., to the environment, supply breakdown, property, financial performance). Employees are actively involved in identifying risks and taking steps to prevent risks becoming a reality.
- **Service co-ordination -** Service co-ordination draws on the experience of other service teams, suppliers and customers to meet customer requirements effectively. Co-ordination between these three groups ensures that disruption to the core business is minimised. Representatives with responsibility for co-ordination are appointed, and co-ordination methods are agreed.

2.4 Level 3 – Knowledge Management

A level 3 organisation builds on the achievements of level 2. At this level, the organisation has the capability to capture and share knowledge across the organisation. So far, the SPICE FM research has had less focus on level 3, which is anticipated to be the subject of future research.

2.5 Level 4 – Quantitatively improved & Level 5 - Continuously improving

So far, the SPICE FM research has had little focus on level 4 and 5. At Level 4, the organisation will have a programme that measures productivity and quality for important process activities related to service delivery. This programme forms an objective basis for measuring the process, customer satisfaction, and harmony across the supply chain. Organisations gain control of service delivery by narrowing variations in process performance, so that they fall within acceptable boundaries. Meaningful variations can be distinguished from random variations. The expectation at level 5 is that the entire supply chain is focused on continuous process improvement. Level 5 organisations can identify weaknesses and strengthen processes before any problems emerge, and can do so in a collaborative manner. Data on the effectiveness of the process is used to perform cost benefit analysis on any new technologies and on proposed changes to processes. This increased level of understanding allows organisations to consider large-scale changes to their processes. Innovations that exploit best practice are identified and adopted throughout the organisation.

3. Process Enablers

Anecdotal evidence from the research suggests that if managers are asked: "Do you implement level 2 key processes?" they are likely to respond "yes". On the other hand, current studies indicate otherwise. So how can managers ensure that they are performing the key processes adequately? The SPICE FM research has identified five process enablers, which are either activities or modes of thinking. These enablers are pre-conditions for implementing the process. They are based on principles established in CMM® [2] and SPICE [3] that were developed for the software engineering and construction sectors respectively. Process enablers focus on the results that *can be expected* from a key process. This is a forward-looking approach, which indicates an organisation has process capability *before* a process takes place. Process enablers detail the features a key process must have before it can yield successful results. Ensuring that all the process enablers are in place improves the performance and predictability of key processes. Process enablers apply across all the key processes.

- **Commitment -** This involves an organisation taking action to ensure that the process is established and is lasting. Typically, this means establishing policies that are shared by the whole organisation. Some processes need sponsors or leaders in the organisation. Commitment ensures that leadership positions are created and filled, and that the relevant organisational policy statements exist.
- **Ability -** This describes the conditions that must exist before a process can be implemented competently. It normally means having adequate resources, an appropriate organisational structure, and training in place.
- **Verification -** A verification procedure checks that activities are performed in compliance with the agreed process. Adopting such verification checks as a process enabler emphasises the need for independent quality assurance. The focus is on *external* verification of processes.
- **Evaluation -** This involves internal process evaluation and reviews to help control and improve processes. During the early stages of maturity, this will mean efforts by the team to improve existing processes. The focus here is on the project team's *internal* improvements.
- **Activities -** This describes the activities, roles and procedures necessary to implement processes. They typically involve establishing plans and procedures, performing the work, tracking it, and taking corrective

4. Core, support and management processes

Business processes can be divided into three broad types: (i) core processes; (ii) support processes; (iii) management processes. Core processes concentrate on satisfying customers. They directly add value to the product in a way that clients understand. These processes respond to the needs of customers and generate customer satisfaction. Support processes concentrate on satisfying 'customers' within the organisation. They might add value to the business indirectly, by supporting a core business process, or directly, by providing a suitable environment. Management processes are concerned with managing the core and support processes. SPICE FM is primarily concerned with management processes. The underlying philosophy is that if management processes are well performed, they will have an impact on the performance of core processes. SPICE FM does not prescribe how organisations should perform core processes. Instead, it focuses on creating a management infrastructure that allows members of staff to perform core processes successfully.

5. SPICE Applications in the Retail Sector

The SPICE FM framework described above was tested in a series of case studies with FM providers to ensure that its outputs are appropriate to the FM sector and of value in the real world. Members of the research team worked closely with FM providers and clients to test the SPICE FM framework in a variety of real-world scenarios. In this context, this section of the paper documents the findings of one such study, undertaken at the Property Services Department within a leading retail group in the UK.

The primary objective of the case study was to establish whether the concepts behind the SPICE FM framework are applicable and relevant to a FM provider in the private sector.

5.1 Study methodology

A series of meetings with the management team at the Property Services department gained the necessary commitment to proceed with the study. This paper does not disclose the precise source of process capability findings. This ensures that members of staff can speak openly about their perceptions of the organisation. The confidentiality of assessment data was made clear to all members of staff that participated in the study.

As already mentioned, this study aimed to assess the capability of the management processes that support the implementation of the Department's business strategy. Below is a list of the key assessment activities undertaken:

- **Departmental management interviews** - The objective of the interviews was to understand: What management views as the critical issues facing the department; What process capability management believes the department has; How policies and procedures are defined; How communication flows through the organisation; and How process improvement fits into the department's vision.

- **Employee interviews** - A representative cross-section of employees were chosen to participate in semi-structured interviews, ensuring an unbiased view of the organisation.
- **Document review -** The research team reviewed items of documentation that employees referred to in interviews. This was to establish whether such documents actually exist, what form they take and their availability to staff.

A detailed description of the SPICE FM process maturity model is already given. The key processes considered within this study were the SPICE FM Level 2 key processes: - Service requirement management; Service planning; Service performance monitoring; Supplier and contractor management; Risk management (including health and safety); and Service co-ordination. These key processes were assessed against the process enablers, as already described in section 3 above. SPICE FM process maturity model identifies five process enablers, which are types of thinking or activities that are pre-conditions for implementing the process. Process enablers focus on the results that can be expected from a key process. This is a forward-looking approach, which indicates an organisation has process capability before a process takes place.

6. Case Study findings

This section refers specifically to the results and outcomes from using the SPICE FM model within the Property Service department. An important objective of the case study has been to understand how the criteria identified in the SPICE FM process model relate to the department. Using the results of the assessment undertaken during the study, this section highlights some of the areas in which the department satisfies or fails to satisfy the key criteria of the key processes and their enablers.

6.1 Service requirement management

Effective management of service requirements identifies the needs of the organisation and its users. The service delivery team identifies how many tiers of customers it has and how their requirements differ. The team has a clear sense of priority in term of its customers and the service mixes it offers. Service level agreements and performance standards are developed and continuously reviewed to remain consistent with customer requirements. They are also communicated to all staff involved in service delivery. The process meets the needs of both responsive and preventative maintenance requirements

The integrated helpdesk is used by the department to record requests from individual stores. Specialist support is available to the operators to respond to more complex queries. The Property Management System establishes schedule of compliance (asset registers, PPM plans and performance criteria). The asset register names appropriate specialist contractors – including primary and secondary options where appropriate. A combination of on-the-job training and procedures are used to train operators. The supervisor is in the process of expanding this into a more comprehensive training schedule. The move towards an integrated helpdesk has improved resource efficiency and ensures effective backup is in place for busy periods. Out of hours provision has also been addressed.

6.2 Service planning

Service planning establishes realistic schedules of work based on customer requirements. Estimates (e.g., resources, maintenance schedules, budgets, purchasing) are prepared for all work to be performed (e.g., scheduled and reactive maintenance). The department has well established systems in place to plan service provision in line with service level agreements. Service level agreements establish clear expenditure guidelines and budgets for individual chains and allow the department to service chains in line with their specific requirements (e.g., the balance between proactive and reactive maintenance). The department has distinct prioritisation levels for jobs that form the basis for establishing target times. The escalation procedure for prioritisation appears well established and understood by staff. tment has distinct prioritisation levels for jobs that form the basis for establishing target times. Costs for maintenance activities are clearly defined based on a schedule of rates for each contractor (including call out rate / hourly rate). Clear guidelines for approval to proceed are in place based on automatic approval mechanisms. Managers have recognised that efficiency savings can be made through a more intensive planning process. This indicates evaluation of the process is taking place.

6.3 Service performance monitoring

Service performance monitoring ensures that services are delivered in a manner that is consistent with the service level agreements and performance standards established with the customer. Feedback is gathered (e.g., from customers and staff) to monitor customer satisfaction levels. Performance measures (e.g., waiting times, error rates, processing times) are reviewed on a regular basis, with the involvement of staff, and corrective action is taken when service delivery deviates significantly from service plans.

Significant efforts have been made to introduce key performance indicators. The department has a wide range of systems in place by which to monitor its performance. Examples include: Financial reports; Weekly reports; Call statistics; Complaints / complements log; Job Checking report; Quality audits; Work record sheet auditing; Invoice auditing; and Year on year profiles. However, there is little evidence that the new reports and key performance indicators are being linked to the needs of the core business. For example, the department appears keen to demonstrate the importance of the FM function to the core business, emphasising the cost of maintenance and the need for proactive maintenance. However indicators are not being developed to address these issues. Although some feedback is gathered at a branch level, it is sporadic and probably inadequate to provide an accurate reflection of customer satisfaction. Tools such as post project reviews and more comprehensive questionnaires were suggested by staff to address this. Despite the similarity between the chains served by the department there appears to be little or no internal benchmarking. Such systems could be used to demonstrate the effectiveness of a chain's property management strategy relative to others in the group.

It is clear that the department has spent significant resources identifying and implementing improvements to its monitoring and reporting structure and these appear to be largely successful. However two areas were identified by this assessment for improvement: more extensive monitoring of individual maintenance tasks (at a branch level) is required to ensure quality standards are being met. Additional resources may be required to address this issue satisfactorily; and although key performance indicators have been fundamental to the changes in reporting, their relationship to the core business appear unclear.

6.4 Supplier management

This key process involves the selection of suitable suppliers and contractors. Service level agreements and performance standards are established and their performance is continuously reviewed.

Due to the nature of the departments operations (i.e., subcontracting of work to external supplies), there are significant overlaps with comments in other key processes. The retail group operates a strict buying policy that is well communicated and understood by staff. The department has a clear objective to streamline the current supplier base in an attempt to improve services and gain ownership. Related to this is also a desire to move towards total FM - supply, install and maintain. This objective is understood by staff within the department. Service level agreements are in place with the supplier base creating performance standards and establishing levels of cover within different contracts. However monitoring of suppliers is simplistic (e.g., random checks, clerk of works, named and shamed, periodic review meetings) and is felt by staff to be ineffective. There is little data available to establish whether performance standards are being achieved. The department has expressed a desire to introduce more objective incentive targets in the future that will make the service level agreements more comprehensive. The department has recognised that the performance of suppliers reflects on its own image within the Group and is taking steps to address these weaknesses. At the time of assessment, there was evidence of significant shortcomings in the systems for selecting and monitoring the department's supplier base. However it is clear that the department has recognised these problems and is in the process of identifying and implementing steps to resolve them

6.5 Risk Management

Risk management involves identifying and evaluating risks so that action can be taken, either to reduce the likelihood of an event occurring or to limit the consequences should that event occur. Risks are identified in all areas of the business (e.g., health and safety, environmental, supply breakdown, property, financial performance). Members of staff are actively involved in identifying risks and taking steps to prevent risks becoming a reality.

At the retail department, formal risk management is limited to health and safety issues. An external consultant is responsible for the majority of health and safety issues. Consequently it was not feasible to examine the process in detail during the case study. However, the department has a clear reporting structure and systems in place for recording and monitoring health and safety issues. The procedures developed to manage unplanned events suggest some awareness of broader risk management issues within the department.

It lacks a clear directive from senior management to manage broader risk issues. The majority of staff are unfamiliar with the concept of risk management and are therefore not in a position to play an active role in the management of the Group's risk – in particular, an awareness of how their job might impact the core business. Consequently the department's employees are unaware of risk management and have received no specific training. Some escalation procedures are in place to manage the unplanned event. Employees feel that the Group is committed to managing health and safety and in particular, recognise its importance to the core business. The department employs an external health and safety consultant "Safety Works" to investigate health and safety problems. The consultant issues questionnaires and carries out audits to ensure method statements, risk assessments, policies and training are in place. There is a well defined accident reporting structure in place. However the role of the health and safety manager within the department is poorly defined, lacking clear scope and objectives. The significance of the department's operations to the core business suggests that this is an important issue to address in the future.

6.6 Service co-ordination

Service co-ordination draws on the experience of other service teams, suppliers and customers to meet customer requirements effectively. Co-ordination between these three groups ensures that disruption to the core business is minimised. Representatives with responsibility for co-ordination are appointed, and co-ordination methods are agreed.

The restructuring of the department to offer a cross chain service has improved integration and communication internally. The relationship between the department and individual stores is remote due to the work being performed by external suppliers. The department has little insight into the effectiveness of the suppliers' co-ordination with individual stores due to the poor monitoring of individual jobs. The 'Vision' process is actively bringing together different sections of the department to improve service delivery. By addressing operational management and reporting issues collectively, this should aid process integration. However, the membership of the Vision group remains small. Some of the department's systems have not been effectively integrated to reduce duplication.

It is clear that integration and co-ordination have improved in recent months as a result of the significant changes taking place within the department. The main weakness concerns the relationship between the department and the customer, due to the poor supplier monitoring and communications currently being utilised. This issue should at least in part be addressed by changes to supplier management monitoring process.

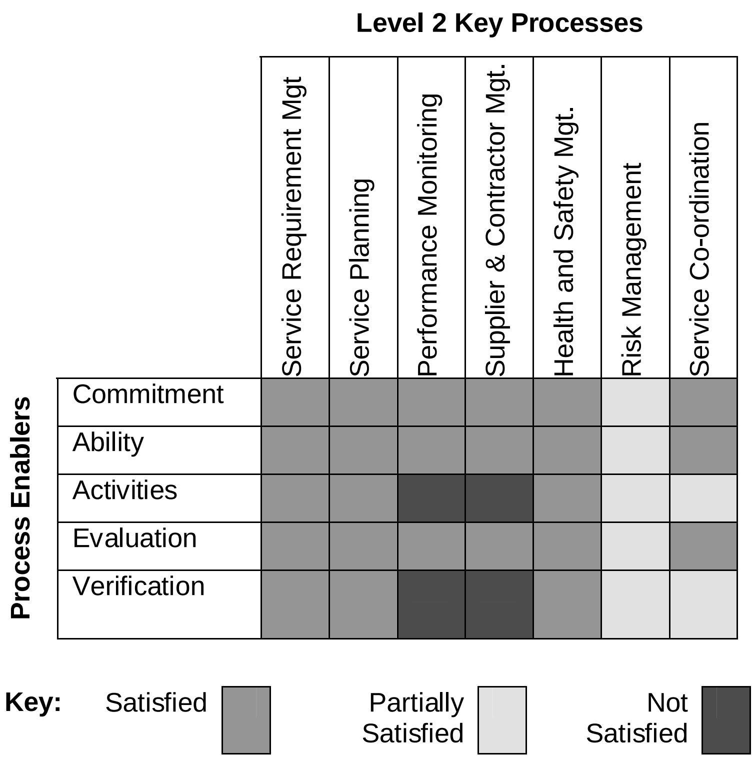
6.7 Process Evaluation and Verification

Evaluation involves basic internal process evaluation and reviews. These internal evaluations are used to help control and improve processes. During the early stages of maturity, this translates into efforts by the team to improve existing processes. The focus here is on the project team's internal improvement efforts. A verification procedure checks that activities are performed in compliance with the agreed process. Adopting verification as a process enabler in turn emphasises the need for independent verification by management and quality assurance. The focus is on external verification of processes.

The department is progressing with a significant change programme, supported by a dedicated resource to identify and drive improvements. A comprehensive "joint action plan" is in place to continually evaluate its operations, identify improvement areas and establish actions based on those requirements. Each action is assigned to specific staff and has clear target implementation dates. The "joint action plan" has a relatively small membership base, making it difficult for some employees to have an input into the process. The quality of communication to those employees has been variable. Consequently, everyone is aware that changes are taking place but the effect of those changes is sometimes not apparent. The value added to the core business through the change programme is not clear. The reporting systems being established within the department provide a checkpoint to ensure that the correct process is being followed. Some formal auditing of suppliers takes place, particularly in relation to health and safety issues. Procedures within the department tend to be informal rather than documented. To ensure that new reporting systems and processes are understood and adopted by staff, it may be necessary to formalise them, including the identification of clear responsibilities and duties. It is clear from the assessment that the department has established a suitable infrastructure to continuously review and improve its key management processes. Verification is also being addressed by this action, through the introduction of a new reporting structure.

7. Summary of process capability assessment

Figure 2: The department's process capability matrix



During the period of the SPICE FM study, the department was part way through a significant change programme aimed at improving the department's processes and reporting systems.

The change programme complicates the findings due to the inevitable collection of contradictory evidence – a before and after scenario. The SPICE FM assessment emphasises the importance of establishing the necessary infrastructure to support and improve processes over time and it is clear from the assessment that the department has allocated significant resources and introduced new systems that address this issue directly. Although the department still has some weaknesses to address, the necessary infrastructure is being put in place to identify and correct these issues in the future. Indeed, because of this infrastructure, many of the weaknesses raised in this report may already have been identified by senior management. Figure 2 is an attempt to summarise the department's process capability against the SPICE FM model. The matrix highlights the mature nature of its processes following the change programme. The main concern surrounding the change programme is the lack of clear strategic direction. Consequently, despite the efforts and likely performance gains the benefits to the core business are likely to remain unclear.

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Encouraging Facilities Managers to Conduct Post Occupancy Evaluations

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Abstract

A range of methods for building evaluation exist. In post occupancy evaluation (POE) methods the focus is on user satisfaction. It is a formal evaluation of buildings made by its occupants after it has been completed, to identify areas that do not meet users' requirements. However these kinds of evaluations are seldom done in Sweden. This paper reports preliminary findings from an ongoing research and development project intended to implement the latest thinking and experience on POE into facilities management practice. The overall aim is to provide the Swedish market knowledge of how to make POE better, faster, cheaper and implemented in practice. Barriers to POEs are scrutinized, as well as suggestions of how these barriers might be overcome. An interview and questionnaire based method is applied. One basic assumption is that results from POEs is essential as input in the construction briefing process, as feedback for productive feed forward. Data generated during an evaluation is suggested to be used in the briefing process for a new building. The results provide insight contributing to the facilities manager's understanding of the potential benefits that an organisation can gain through the use of building evaluations.

Keywords: evaluation, tools, facilities management, briefing/programming*, corporate real estate, end users.

**The British concept construction and design briefing is used as a synonym to the American concept architectural programming throughout this paper.*

1. The Encouraging POE Project

1.1 Overview

This paper report preliminary findings of an ongoing research and development (R&D) project that aims to put into practice the latest thinking and experiences on Post Occupancy Evaluation (POE) and Building Performance Evaluation (BPE) at the strategic and operational levels for, facilities manager, clients, and building occupants. The project is founded by FORMAS, the

Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning, during the period of October 2004 until June 2006.

The overall aim is to bring together knowledge and experience from practice and research, to provide knowledge of how to improve Swedish POE, make them quicker, and cheaper, and to develop compatible, robust methodologies for use throughout the life cycle of buildings, usable for facilities manager among others.

1.2 Industrial Relevance

This R&D project bring together contributors from the industry, real-estate companies, and the real estate division of one county council, one municipality as well as from universities [1], where new ideas about building evaluation can more easily be developed, reach industry's expectations and, methodically discussed.

The practical value of the project is expected as following:

- to consider barriers to post occupancy evaluation across a range of industry representatives
- put forward suggestions as to how these barriers might be overcome
- use the results from a POE as input in the construction briefing process
- In doing so it:
- encouraging the facilities managers improved use of feedback
- presents a way of measure building performance goals adjusted to a Swedish context
- presents barriers to POE as perceived by clients, facilities manager, designers, contractual bodies and POE activists and describes the perceived benefits of POE
- makes suggestion as to a way forward that might overcome the perceived barriers, including alternative means of dispute resolution - encouraging post occupancy evaluation
- outlines POE services offered for facilities manager as an aid for them to identify the purpose of an evaluation before selecting a suitable method.

In terms of the interaction between clients and users it is often suggested that the greatest improvement would come through the provision of systemised feedback and in instituting post-occupancy evaluation. It is unrealistic to expect buildings to operate perfectly at handover, some degree of post handover tuning are essential. In response to Rethinking Construction [2], The British RIBA Practice Services proposed a move towards making POE a standard service. This project will survey the Swedish conditions for such an approach and the conditions for the facilities managers taking a more offensive part in the evaluations process.

2. Post- Occupancy Evaluation and Value Management

Post-occupancy evaluation (POE) is the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time - a definition of post-occupancy evaluation offered by Preiser et al. [3]; [4]. The evolution of POE begins with unique case studies in the late 1960s and continues to system wide and cross-sectional evaluations in the 1970s and 1980s. These assessments focused mainly on the performance of buildings. Now days' building performance evaluation (BPE) and universal design evaluation (UDE) stress a more holistic, process-oriented approach to evaluation. Prieser [4] emphasize that this will lead to that not only facilities, but also the forces that shape them (political, economic, social, etc.), are taken into account.

In the future, Prieser [4] expect more process-oriented evaluations to occur, especially in large government and private sector organizations. Ideally, the information gained through POEs is captured in lessons-learned programs and used in the briefing, planning, and design processes for new facilities to build on successes and avoid repeating mistakes. Consequently, POE is not the end phase of a building project; rather, it is an integral part of the entire building delivery process. It is also part of a process in which a POE expert draws on available knowledge, techniques, and instruments in order to predict a building's likely performance over a period of time. In this sense, a process is understood as a bounded group of interrelated work activities providing output of a greater value than the inputs by means of one or more evaluations.

The concept evaluation include value, thus, occupant evaluations must state explicitly whose values are referred to in a given case. An evaluation must also state whose values are used as the context within which performance will be tested. This research and development project focuses on the values behind the goals and objectives of those who wish their buildings to be evaluated, in addition to those who carry out the evaluation. Value, in its relevant sense, describes benefits to the client and can be quantified in business terms; for example, value describes the improvements patients experience during treatment, or the value an employer or an employee receives from creating a better working environment. Kelly et al. [5] define value from the client's point of view as a relationship between cost, time, and quality where quality includes esteem, exchange, and use. Furthermore, Kelly et al. [5] defines a value system as the representation, at a fixed point in time, of a discrete range of variables against which all decisions affecting the core business or a project can be audited. The variables are determined by time, cost, and quality. Value Management (VM) is a planned, multidisciplinary group decision-making process that supports the improvement of the value of a project, process, or product in a manner consistent with the business goals of the stakeholders and customers [6]. While this often leads to cost savings, more importantly it provides the best outcome for a project by considering a variety of evaluation criteria. These assessment criteria are most useful in POE:s and help clients, facilities managers and other stakeholders identify a desirable building project

The understanding and fulfilment of requirements is also closely related to the concept of quality, which is a measure of the extent to which requirements and expectations are satisfied in relation to their own set of values [7].However, this research project focus on the construction client as one major stakeholder for such an evaluation and the Facility Manager as the adviser in quality evaluation matters.

2.1 Experience from Existing POE Methods

From current research and practice [4]; [5] certain types, or levels of effort of POEs can be identified. For example: -indicative, investigative, and diagnostic as well as its different phases – planning, conducting, and applying. These can also be divided in two main categories – user based evaluations or expert based evaluations. The facilities manager role is to be familiar with the different types of POE:s and recommend whether more or less expert-oriented methods is needed. Hence, qualified evaluators usually carry out the process and users contribute at the request of the evaluators. The facilities manager is thus assumed take responsibility of the planning, preparation, selection of interests groups, as well as review of the evaluation.

Within the limitations of this paper, it is not possible to completely describe the different POE types. However, this paper would not be comprehensive without concise accounts of these types.

Indicative POEs give a hint of the most important strength or success as well as weaknesses or failures of a building overall performance. Data collection is made fast and easily available. Indicative POE:s usually consist of selected interviews with well-informed staff members, as well as a subsequent walk-through evaluation of the facility. The typical outcome is understanding of issues in building performance and recommendations presented in a short report.

Investigative POEs go into more depth, often as a second stage after that a problem has been identified during an indicative POE. This level of evaluation relays of a more sophisticated data collection such as for example comparison with reference buildings as one way to identify the reason to problems. Evaluation criteria can also be found in the functional briefs, or have to be assembled from guidelines, performance standards, or available literature on the specific building type. The result from an investigative POE is presented in a report and gives a more thorough understanding of the foundation and matters in building performance together with plans for action.

Diagnostic POEs contains of a multi–method strategy, counting questionnaires, surveys, observations and physical measurements by the intention to compare physical environmental measures with subjective occupant measures. The outcome is usually long-term oriented as the results after several months of assessment generate new knowledge about the performance of the specific building as more general aspects of the whole category of that particular building type.

For each level of POE there are tree phases - planning, conducting, and report of findings. In this R & D project the facilities manager is suggested to take the responsibility for the planning phase and preparations of the POE project. One assumption is that the facilities manager should be able to identify the purpose of the evaluation and after that select an appropriate level of conducting the POE. This assignment includes investigation and feasibility, resource planning, and in case of need even research planning together with qualified evaluators. The facilities manager is thereby responsible for that the constraints for the POE project are well-known by the participants. The facilities manager is also responsible for the schedule, costs, and skills needed. When the evaluation is completed the facilities manager should report the findings in a proper way to staff members as well as to the facilities department as an outlook for future action.

3. POE for Construction Clients and Facilities Manager

In much of the recent debate on the construction industry, construction clients are pointed to as the major steering force for directing the construction processes and results [8];[9]; [10]; [11]. The construction client is also responsible for ensuring that wishes and preferences of the end user are met and that all laws and regulations are complied with. A construction client is a person or organisation that contracts the construction of an object (a building, road, bridge, facility) [12] either for their own use or someone else’s. The construction client may be the real estate owner or the one who orders the proposed construction. Sometimes, but not always, the client is also the user of the building. Regardless, the construction client often represents many different interests in terms of required services, functions, designs and interpretation aspects. This is a function that represents the owner’s interests, perhaps even representatives of the client, the end-user, the operations that will use the facilities and different groups and organisations that in one way or another are influenced by the proposed planning, production, operation, and/or demolition process.

The basis for being able to satisfy the needs of the client, however, is a good understanding of the client’s situation, which demands effective means of working within the construction and management processes [13]. Large client organisations who procure new buildings on a regular basis, the maximum value only can be achieved if it is used in conjunction with an ongoing commitment to post-occupancy evaluation. Construction briefing and POE:s is seen to provide the means of ensuring that an individual building design satisfies an organisation's strategic property needs. However, it is also necessary to recognise that an organisation's strategic property needs will continually be in a state of change. As the Facility Manager have the responsibility to strategic planning, aligned to business needs and demonstrating contribution to archiving explicit business needs this acquire effective change management in combinations with evaluations skills. Consequently, economic and functional under-performance can only be avoided by regular performance evaluations of existing facilities in accordance with changing requirements [14].

4. Systematic Feedback to Improve the Briefing Process

The less well exploited opportunities for improving performance, reducing costs and abortive design time lie in the rationalisation of the client's briefing and evaluation process. The major focus has been on improving the construction design and delivery with much less concern for achieving gains by rationalising the client briefing and evaluation. The improvement of the client briefing and evaluation process by systematising the gathering and application of feedback from completed projects to improve the construction industry productivity, building performance and user satisfaction.

This R & D project will encouraging the improved use of feedback particularly for clients with continuous building programmes that will facilitate the prescription of tried and tested solutions yet allow and encourage value-adding innovation in a controlled manner.

5. Preliminary Findings – Feasibility Study

In order to understand the problems and barriers to POE:s one initial feasibility study were carried out. This investigation includes literature studies and a workshop with the industrial partners. The findings from literature studies regarding the use of post occupancy evaluations and the tools utilise will be combined in order to provide a deeper understanding of the mechanisms that are fundamental for minimising the barriers of innovative post occupancy evaluations. The workshop provided some preliminary findings that are to be compared with the outcome from future following interviews, a comprehensive questionnaire and deeper analysis of the literature study.

Preliminary results indicate that:

- There is a call for for checking that the desired objectives are met. The industrial partners' claims that thorough requirements are not met in the final product too often. However, the partners neither conduct nor have appropriate verification methods for assessing the desired performance of given building properties.
- The partners wish to ensure that the desired performance targets will be fulfilled. And if this is not possible, they want to know this beforehand. There is a call for early and continuous verification to take place in the design process and not only as a post occupancy evaluation.
- Expectations, goals, and objectives for the evaluation program are to be stressed. The focus of the evaluation /POE information-gathering process has to be more expressed towards respondents.
- There is a wish for feeding back the results of a POE to building practice, enable or constraining the performance approach and its benefits. Information gathered through evaluations/POEs should be tied into feedback loops for planning, briefing, and capital asset management.

- The partners seek for arguments, criteria and driving factors for establishing whether an evaluation should be conducted or not - with the intentions to empower the facilities manager.
- The facilities manager has an important role in being familiar with different types of POE:s and recommend whether more or less expert-oriented methods is needed. The facilities manager is also assumed to take control of the planning, preparation, selection of interests groups, as well as review of the evaluation.

The next steps in the process are as follows:

1. Start-up (October 2004 – mars 2005): A feasibility study in the form of studying the participating partners POE tools, perspective and other background material. Planning of the following empirical study, and the formulation of questions for the interviews and questionnaires. Contact with key persons within selected construction client organisations.

2. Data collection and theoretical analysis: Data collection, retrospectively by a detailed evaluation of a selection of the industrial partners recently completed new- build and refurbishment projects. The carrying out of the first series of interviews based on the selection strategy from the feasibility study. Preliminary analysis. Interim presentation in the form of POE-seminars. The formulation of questions for follow-up questionnaires.

3. Continued data collection and theoretical analysis: Follow-up interviews and implementation of questionnaire study. Continued processing and analysis of the case-study data gathered in. Workshop techniques with the industrial partners and members of specialist occupier-focused organisations with various backgrounds such as health, education, academic institutions, housing, and others.

4. Analysis of data and final report (June 2006): The final report, a national implemental POE tool and efforts to spread the findings of the project. Opportunities for improvement developed through workshops into a generic briefing and evaluation framework appropriate for organisations with continuous building programmes.

6. Conclusions

In the framework of this R&D project the participants have stated that the assignment for the future work is to:

- focus on tools and techniques for management of requirements throughout the entire construction and design development process by making available internationally based briefing and evaluation support methodologies, tools and concepts through research, management, execution and dissemination.

That is the goal we are pursuing for and it goes beyond merely establishing a set of evaluations tools. As presented earlier in this paper there are already progresses in parts of the briefing process but big gaps still exist in the evaluation process to really enable the mission statement to be realised.

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A Simple Reliability Analysis of Essential Services in a Building

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Abstract

In a hot tropical climate it is important to have building services functioning in such a way as to provide a suitable level of functionality and comfort for the normal use of that structure. A fairly modern university building in which high levels of sustained concentration are expected to be maintained needs certain basic standards of service, such as those of lighting, ambient temperature and availability of water for drinking, washing and waste disposal. A study was undertaken of a particular building of this description that has suffered from fairly regular interruptions in service ever since it was completed. A study was undertaken to record the interruptions to services to the building during the year 1999, and a simple reliability analysis suggests that the level of service was below what should be considered acceptable.

Keywords: essential services, electricity, air-conditioning, water, probability.

1. Introduction

When a building is being designed and constructed one of the key parameters that must be taken into account is the functionality and comfort for the normal use of that structure. The building's performance when in use can be affected by its design, its construction, its maintenance and by factors that are external to the building. The ideal is to provide a building that is comfortable, efficient, safe, healthy and durable. The recent focus on 'sick buildings' in various parts of the world has also brought home the economic impact of malfunctioning building systems in terms of the human costs incurred. The huge increases in energy costs have also alerted building designers and users to the importance of energy in the life-cycle costs of buildings, and increasing general awareness of the issues related to global warming and sustainability have also served to change the focus of building system design.

In a tropical climate, as exists in Trinidad & Tobago, design practices nowadays take into account most of these factors, however, the University of the West Indies has a significant legacy of buildings completed more than a decade ago in which the design parameters were less far sighted. There are also differences between building designed and constructed in the optimism of boom periods, and those constructed during the pessimism of a slump. In the former case, for example, less attention was paid to sustainability and life cycle cost issues than in the latter. This has had far reaching implications for the long-term facility management of these buildings.

Little systematic research has been done into the performance of the buildings within the University Campus so a start has been made into the recording of the breakdown of the systems in place in order to establish the sacle of the problem, and then to diagnose, explain and attemp to provide solvutions to the failings identified.

2. The Building Systems

In a tropical climate the design of buildings for comfort must address, particularly, the flow of heat from outside, as well as disposal of the heat build up from occupants and appliances inside the building. In old-fashioned structures the design encouraged cross ventilation using the tendency for heat to rise as well as the natural wind patterns to keep the internal spaces cool. Very modern buildings use photo-voltaics and solar energy and limited air conditioning to assist nature. However, buildings designed and constructed during the boom years of the late 1970s and early 1980s in Trinidad & Tobago, made no such concessions. Although the standards and regulations regarding what are considered essential building services have not changed significantly, the approach adopted by most architects has. The result has been that a number of the buildings of that period have proved to be problematic in operation, and have had to be retrofitted with systems designed to improve their performance. This is not to say that the buildings were badly designed for the time when they were designed. They were well designed given the knowledge and objectives of the period, however, things have changed since the building was completed. [1]

As an example, the building in question was designed as a solid, box-shaped, mass-concrete structure, in which the separate rooms and offices needed to be air-conditioned. The system chosen was a water-cooled system, with fan-based blowers in each room. It was also designed on the premise that it was cheaper to leave the lights on inside the building permanently than to install switches and allow occupants to turn lights on and off. The reduced wear and tear on bulbs and the saved expense of installing wiring and switches was felt to more than offset the cost of electricity being wasted in empty rooms. In addition there was the benefit of the aesthetic cleanliness of walls without wires and switches. As time has passed, the logic behind these choices has become suspect.

The key services to this structure are those that make it usable in the most basic sense. Because of the building’s configuration and structure, it experiences significant heat gain during the day and because the building is designed to be closed up (i.e. the doors have return springs to close a door after it has been opened) it has very little natural ventilation. As a result air conditioning is essential – all the more so in rooms like lecture theatres where relatively large numbers of people gather for extended period, and computer laboratories where the equipment generates significant heat. Because the air conditioning is water based, it is necessary to have water to feed the system, and electricity to activate the blowers. In a building in which staff and students need to be able to read and write documents of various kinds it is obviously necessary to have adequate lighting, which again requires electricity. Similarly in a large public building where people will be spending a major part of the day it is necessary to have water available for drinking, washing and the flushing of toilets. The lack of water for air conditioning also signals a lack of water for fire fighting, and this threatens security as well as comfort levels. Thus, if any one of these three services (air conditioning, electricity and water supply) is unavailable the building becomes very un-user-friendly.

3. System Reliability

Reliability is a broad term that focuses on the ability of a product to perform its intended function. Mathematically speaking, assuming that an item is performing its intended function at time equals zero, reliability can be defined as the probability that an item will continue to perform its intended function without failure for a specified period of time under stated conditions. [2]

Engineers undertake reliability analysis in order to measure and predict the reliability of mechanical or electrical components and systems. Measurement is based around the occurrence of failures, and analysis depends largely on statistical probabilities. The probability of the survival times for components and systems can be used to help predict their life expectancies. The more complex the set of components and their interdependencies that maintain a system in effective operation, the less reliable that system becomes. When that system is one on which our comfort and convenience depend then it is unfortunate when it breaks down; when it is one in which failure can be life-threatening then it is critical.

A simple measure of reliability can be obtained in terms of the proportion of the actual recorded observations relative to the total instances on which an observation could be made. This can be represented in one of two ways, as shown in equations (1) and (2):

$$\text{Reliability} = \sigma_{(\text{actual measure})}/\sigma_{(\text{total possible observations}} \qquad (1)$$

$$\text{Reliability} = \sigma^2_{(\text{actual measure})} / \sigma^2_{(\text{total possible observations})} \qquad (2)$$

In the case of equation (1) the reliability is measured as a simple ratio of the number of occasions when a service is not available to the total number of occasions when it could be available[1], and

[1] What we are doing here is to use a raw count of occasions when a service has been unavailable in order to determine its frequency – and hence the relaibility of the system. In the example of the air conditioning there were 105 days on which the service was out of action out of a total of 250 possible days, so the

where a system involves a number of independent processes working together, identified as $\sigma_1, \sigma_2, \sigma_3$ for example, the value of the reliability index is derived as the multiple of the separate ratios, hence:

$$\text{Reliability} = (\sigma_1/\sigma)(\sigma_2/\sigma)(\sigma_3/\sigma) \qquad (3)$$

In the case of equation (2) the total system reliability is given by the sum of the individual measures, and because we are not dealing with variances here, the use of standard deviations is not really appropriate. However, the strength of the relationship between two states is sometimes expressed by squaring a measure of their interaction (the correlation coefficient) and multiplying by 100[2], it may be acceptable to measure the overall reliability of a system by squaring the reliability index for each parameter affecting the system and adding these values. The reason why squaring the index may be appropriate is a result of the way in which correlation is defined, hence

$$\text{Reliability} = (\sigma_1/\sigma)^2 + (\sigma_2/\sigma)^2 + (\sigma_3/\sigma)^2 \qquad (4)$$

There are much more complex models of reliability available based on such measures as the mean time between failures (MTBF) for example, however, given the coarseness of the data acquired for this study, the equations here are more than adequate. The reliability values obtained from these two simple models are compared to see what difference in reliability is indicated.

4. The study

The building used in this brief study was the civil engineering building, known as Block 2 at The University of the West Indies, St. Augustine, Trinidad & Tobago for the year 1999. The basic methodology was to keep a daily record in a desk diary of the occasions on which any or all of the specified services were non-functional. Because of the coarseness of the raw data, the lack of explanation for the events causing loss of service and the preliminary nature of the study, no detailed statistical analysis has been undertaken. All that has been done is to calculate the values of two alternative ‘reliability indices’ that can indicate the overall system reliability - where:

P(x) = Probability of an event x

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measure of reliability is that on 42% of working days, there was no a/c. This approach is used because of the familiarity of the concept of a percent frequency.

[2] The resulting statistic is known as variance explained (or R^2)

A = Air-conditioning malfunction

E = Electricity outage[3]

W = Disruption in water supply

$P(x) \approx$ [(Number of days failure occurred)/(Total number of working days 250)]

$P(A) = 0.42$

$P(E) = 0.04$

$P(W) = 0.27$

Assuming that P(A), P(E) and P(W) are independent processes, the probability that on any given day the three essential services are concurrently **working** is – using equation (3):

$= (1 - 0.42)(1 - 0.04)(1 - 0.27) = 0.58 \times 0.96 \times 0.73 \approx 0.40$

and the probability that on any given day the three essential services are not concurrently working is – using equation (4):

$= (0.42)^2 + (0.04)^2 + (0.27)^2 = .176 + .0016 + .073 \approx 0.25$

Giving a probability that the three essential services are concurrently working on any particular day as around 75%. Instinctively this 'feels' like a more reliable value for the probability of the all the systems working, given the practical experience of the day-to-day serviceability of the building. The value of 40% for the building availability is very low, and although it was a particularly bad year, it seems unlikely in retrospect that it was so bad. It must also be noted that there were breakdowns of various systems that lasted for extended periods, such as several weeks without air conditioning. So the values do not represent discrete occurrences of breakdowns of particular days, but rather an overview of the effect of breakdowns on the system.

It must be said that the 'better' value for the probability of all systems working, of 75%, is not very good, as the failure of any one of these systems is sufficient by itself to make the building virtually uninhabitable. The problems that are responsible for this poor level of reliability are almost entirely extrinsic. The supplies of water and electricity which govern the functioning of the building support systems are public utilities outside the building and the campus, over which nobody within the University has control. However, the choice of a water cooled air conditioning

[3] This does not include voltage surges or short term, transient outages.

system built in an extra mode of failure for this critical system – it fails when there is no current and it fails when there is no water. In addition the choice of a central air conditioning system means that when it is down, none of the building is properly usable. The central system is also running all the time, cooling the building even when it is empty. Although it would have been a larger capital expenditure at the outset, much more flexibility and economy in operation would have been achieved by designing individually controlled air conditioning systems with thermostatic controls that automatically cut off when the temperature reaches its design level.

5. Conclusions

Obviously it is desirable to have a building that is used for University staff and lectures available almost 100% of the time. Thus it is necessary to improve the reliability index of the building's availability from its current value of around 75% up to around 100% by improving the systems that cause it to be unavailable. There are various techniques available to help identify problems and solutions including Fault Tree analysis and Failure Mode and Effects Analysis. These techniques can highlight the effects of failures in elements of the design in order to help find ways to reduce the probability of a loss of service occurring.

An economic cost-benefit analysis can help to identify which amongst the technically feasible solutions are economically feasible as well. Given the change in the economic parameters that exist nowadays compared with those that existed when the building was designed and constructed, it is almost certain that the support systems are not optimized for today's market. Given also the failure of those systems to provide a sufficiently reliable building in terms of its availability, then there is a clear need for a review of its critical design characteristics. The two key elements are electricity and water, and if the supply provided by the public utilities is inadequate, then the building systems need to be designed to take this into account. Depending on the cost functions, this may mean either building storage for sufficient water and installing stand by generating capabilities or redesigning the systems to operate differently.

It also seems likely that the economic efficiency of the system is now poor given that there is a lot of waste of energy through air conditioning and lighting that is not turned off when rooms are not occupied. Although this does not show up in the analysis carried out for this study, it is an observation that is hard to avoid.

6. Acknowledgement

I should like to express my gratitude to my colleague Dr Gyan Shrivastava[4] who kept the detailed records of the availability of services in this building, on which this commentary was based

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Demonstrating the Added Business Value - Appraisal of Tools and Methods

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Abstract

This paper is concerned with the appraisal of current workplace performance measurement tools and methods, and identifying flawed understanding within them to distinguish how they could be further developed to enable better demonstration of added business value through workplaces. Thus this paper presents an exploratory framework (rather than a review of previous work) for those facilities/workplace managers as well as academics and consultants who are keen to develop business oriented workplace performance measurement tools.

Practice-initiated problems have been used as a basis for this research, representing a timely, real world, enquiry. The aim of the research was to reflect on and critically appraise the current tools and methods documented in literature and used in practice - 14 varying tools were identified and examined. The setting of logical and comprehensive criteria for the critical appraisal became a fundamental challenge -better understanding of different approaches to workplace performance measurement was needed. This was achieved through a parallel review of the Centre for Facilities Management's case study database and through a literature review. Further interviews were also carried out with the FM practitioners to confirm the findings and to better understand their practice of workplace performance measurement.

Gap analysis of the identified methods and tools, and the proposed criteria was undertaken. It was recognised that these tools and methods place little emphasis on supporting the continuous change within organisations and that an understanding of people activities, such as communication and team interaction, was under developed. Paper concludes with recommendations for further development for workplace performance measurement tools and methods.

Keywords: workplace performance, tools/methods, Facilities Management, usability

1. INTRODUCTION

The competitive market has pressured companies to produce more, to a better quality, in less time with fewer resources, hence the drive to increase business productivity and cut costs. At the same time the nature of work is becoming less tangible and the employees are increasingly considered as the most valuable resource of an organisation. One consequence of this is that the relationship between an organisation's measured resources and its market success has become tenuous[1]. This leaves organisations in a situation where core competencies, such as the ability of employees and teams cannot be tangibly measured and listed on balance sheets. Nevertheless, the traditional approach to increase productivity has been to reduce costs and especially costs not directly involved in creating tangible value are usually the first ones to be scrutinized [2]. In the field of facilities management this has meant that the need to demonstrate the contribution made to improve productivity has intensified. Nutt et al.[3], for example, suggests that two of the key questions for the future of FM includes how to create, quantify and demonstrate linkages between FM and business, and how to assess and measure the contribution of FM to improving business productivity. One fundamental attempt to illustrate this contribution has been directed toward high performance workplaces – and the demonstration of the business value through workplaces. This has meant that facilities managers and other related disciplines have to go beyond the traditional methods of controlling costs and maximising the value of the built assets by utilising space, by placing more emphasis on the impact workplaces can have on the performance of the people.

Similarly, in addition to the general discussion in the field, the practitioner-led Facilities Management Forum (facilitated by Centre for Facilities Management and led-by senior managers of large UK/global organisations[i]) initiated, in 2002, a research enquiry to gain more knowledge about workplace performance measurement and associated tools to provide a framework for the demonstration of the business value. The Forum group agreed that [4]:

1. *The FM practice suffers from an over-emphasis on cost reduction, which limits the ability to demonstrate potential workplace improvements due to the insufficient evidence of the value these would add to the business.*
2. *They also suggested that 'one reason for this is a lack of workplace performance measurement knowledge' as the measurement of workplace outputs has until recently been largely non-existent*
3. *Those measurements being developed focus on the efficiency in Facilities Management processes (such as cost against cleaning process), rather than the development of effectiveness measures (such as contribution of clean buildings to the reduction of sickness and absenteeism), which would create a link between Facilities Management input and output and would be seen as a contribution of FM to the core business.*

[i] The CFM forums facilitate the open exchange of facilities management best practice and provide structures for a non-competitive environment to debate common issues, concerns and market trends. The CFM forums work on an action research basis (as defined in Alexander *et al* 2003) and therefore the main principle in the collaboration is to narrow down the research interests through the activities and interests of the participating organisations. Forums operate in two ways. In the first instance, there are workshops, which encompass discussion and debate about topical FM issues, with guest speakers from within and outside the industry driving forward the discussion themes in a bid for breakthrough solutions. In the second instance, forums generate long-term research projects.

4. *Further it was identified that there is a lack of qualitative measures. It was suggested that metrics that fail to measure quantitative and qualitative performance outcomes may depict an inaccurate picture of what really happens in the organisation.*

From these issues the practical enquiry (as used in the forum) was formed: ***How to demonstrate the business value of improved workplace performance?*** This enquiry motivated the authors to carry out further investigation, with more theoretical rigour, to run parallel and subsequently to the implementation of a workplace performance framework developed for this forum activity. It was believed that a more thorough understanding than was possible to be gained within the business timescales was needed and therefore the practical enquiry was lifted from the forum for the purposes of theoretical reflection.

Subsequent interviews with the practitioners within the six case study organisations further validated the forum enquiry. The following statements were recorded when senior managers were asked about their concerns associated with workplace performance measurement :

- *'The facilities management calls for a means of collecting 'soft' data to support better management decisions.'What should Central Services do in order to reflect the corporate value in physical workplaces?*
- *'What would the appropriate tools for measuring the performance of FM be that go beyond the focus on 'cost per' and are valued by the business?'*
- *'How can we implement flexible workplace concepts to meet business needs in terms of trust (related to staff absence), communication between managers and employees and team working to support off-site working?'*
- *'How to improve the employee's working environment to enhance performance?'*
- *'How to measure office effectiveness and to demonstrate that certain layouts have increased input?'*
- *'How frequently workplace performance should be measured?'*

In this context, these practical enquiries were expanded upon to define research questions and the scope. The following questions were created:

1. *What requirements can be identified in literature and in practice for the measurement of workplace performance to enable the demonstration of the value of the workplace to business?*
2. *What tools and methods that aim to demonstrate value are currently documented in literature and used in practice and what do they actually measure?*
3. *How do these tools meet the set theoretical and practical requirements identified?*

The paper first describes a research process, emphasising a practice-led research approach. In turn, this is followed by three sections, each providing identified answers to the three research questions presented above.

2. RESEARCH PROCESS / METHODOLOGY

2.1 Practice-led research

Instead of following the conventional approach of identifying research problems through an extensive literature review and aiming to find answers to these (theoretical) problems through investigations within practice, this research emphasises the importance of defining the research topics through understanding the practical enquiries in the field (of FM). Thus, the participation of practitioners is fundamental to the usefulness of the research undertaken, as they contribute to the research process and the monitoring of the relevancy of research to practice. The importance of involving practitioners in the defining of a problem has been emphasised [5,6,7,8]. Lawler [5] states that: '*clearly the researcher ought to offer expertise about theory, past research, and methodology, but needs to rely on the members of the organisation to provide expertise about the practise. For this to happen, the practitioner has to be involved in the study at a more than superficial level and, indeed, has to influence both the kind of topic studied and methods used*. It has also been recognised that the thorough knowledge of prior research is very important, it is very rare for good research ideas to be derived directly from literature [6].

2.2 Research process

The practice-led research process and methods used are presented in the Figure 1. The research questions (as presented above) were narrowed down through a content analysis of the problem defining process of a FM practitioner-led research forum and through an initial literature review. As the setting of logical and comprehensive criteria for the critical appraisal became a fundamental challenge - a better understanding of different approaches to workplace performance measurement was needed. This was achieved through a parallel review of the Centre for Facilities Management's case study database and through a literature review. Further interviews were also carried out with the FM practitioners of the research forum, but also with other case study organisations (to gain a broader view) to confirm the findings and to better understand their practice of workplace performance measurement (six case studies).

As a result, exploratory criteria were developed and further examined. Parallel to the case study investigations, eight workplace performance measurement tools/methods were identified within literature. A gap analysis was carried out to define how the tools used in practice and identified in literature met the created criteria for workplace performance evaluation, providing suggestions for the further development of measurement tools.

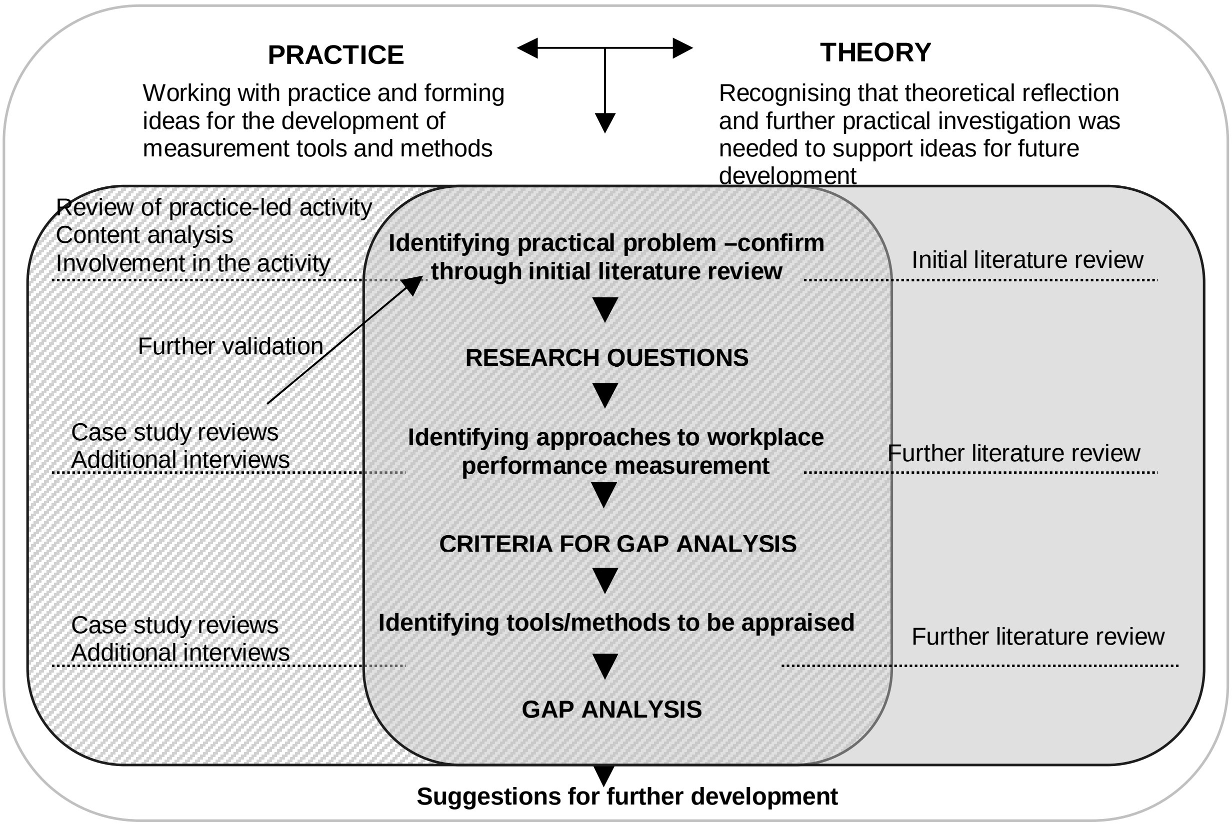

Figure 1: Parallel research process of practical and theoretical reflections

3. WORKPLACE PERFORMANCE MEASUREMENT

Research Question 1: *What approaches/ requirements can be identified in literature and in practice for the measurement of workplace performance to enable the demonstration of the value of the workplace to business?*

As the authors' aim was to define what is meant by workplace performance and what elements it consists of (to better understand what should be measured) different definitions, and practical examples were initially examined. It was recognized, as the nature of practical enquiry demonstrated, that amongst practitioners there was a clear lack of definitions for workplace performance. Instead, it became more relevant to understand what was driving measurement in the case study organisations. The following drivers for practice approaches were provided:

- Need to develop other means of collecting 'soft' data to **support better management decisions**.
- The results need to be transferable into reasonable indicators to **feedforward** to probability cash flow

- **Identifying spatial needs -** focus on collecting information concerning work functions- what facilities are used and when.
- Collecting information on the **current situation -** to understand where the company is now and **what should be improved**
- Providing a further benefit of data collection as to **illustrate change** (improvements) over time.
- **Identifying the major issues** relating to the ways of working
- External benchmarking comparisons are seen as a useful **reassurance** that the service is competitive/effective compared with other market benchmarks.

These identified, practical, purposes for measurement reflect on literature. Nani et al [9] see performance measurement as a means of monitoring and maintaining organisational control to ensure that strategies that lead to the achievement of overall goals and objectives are pursued. The purpose of performance measurement is also to clarify *organisational success* and to *inform and guide change* (continuous, improvemental and emergent change and discontinuous change) [10]. It is also proposed that applying disciplines of performance measurement helps to *determine the crucial success factors* for the overall organisation as well as for the delivery of the specific function or operation concerned [11]. Performance measurement is used for purposes of *problem finding and solving*, and it therefore supports efficient decision-making. It also helps to *identify the success of improvements*, determine whether the *customers' requirements are met* and where *improvements* are needed. Further, measurement helps in the understanding of *processes* (in terms of confirming what is known or revealing new) and to *ensure decisions are based on fact* [12,13].

However, even though the drivers were clear, it was recognized that in literature there are numerous different approaches to defining workplace performance, also the terminology was perceived to be inconsistent. Examples of the used terms are: building performance, office productivity, workplace functionality, office environment and facility performance. Therefore, an initial attempt to define the criteria for the evaluation transpired to be complex, and instead, the overall understanding of the approaches was to be achieved through experimenting, at a more general level, different dimensions of measurement. As a result, four different approaches were identified. The distinct division between these approaches was the point of focus on either improving a product or a process. Similarly it was recognised that there was a division between measuring to gain benefit for construction industry and measuring to gain benefit for business itself. These approaches are demonstrated in Figure 2.

Approach 1: Construction Product

It was identified that one approach to workplace evaluation was to evaluate a building. In these cases literature often refers to a building's capability to meet the mandates and health and safety regulations. An approach of this kind is perceived to focus on the physical (tangible) elements that are valued from a quantitative perspective rather than a qualitative one. Also, the efficiency of different elements of the building (products) is assessed rather than the effects of them (on business process). Findings from these kind of approaches are often fed back to the construction industry to reflect on the failures within the building [14].

Approach 2: Construction process

Similarly, the construction industry benefits from evaluating the physical product, and failures within, by reflecting the results on the construction process and how the briefing or management of the process, for example, could be improved.

Approach 3: Product for Business

The focus in this approach is perceived to be on the workplace environment and people (occupiers') perceptions are considered as an integral part of the evaluation. However, people are only considered from a physical well-being point of view and better performance is to be achieved through a well functioning building (air-condition, ventilation, operable windows etc.). Similarly, a well-functioning building is a target when evaluating functionality. Nevertheless, not only the relationship between the physical environment and the individual is considered, but also the fitness (of workplace) for purpose from an organisational point of view is reflected on. Functionality is achieved if the original brief has been met or the objectives of the accommodation plan have been attained [15]. In this instance, also qualitative (subjective) issues are considered (fit for purpose, flexibility etc.).

Approach 4: Business Process

Originating from the product design/software industry, it is proposed that more focus should be placed on people activity. Furthermore, emphasis should also be placed on social and cognitive aspects rather than considering people only from a physical/ mechanical point of view - 'repertoire of action and potential to break down' [16]. Characters of measurement associated with this approach should focus on the users: ease of use, usefulness, user-friendly etc. Usability in the product and software industries is widely accepted as a critical element for a product to be successful.

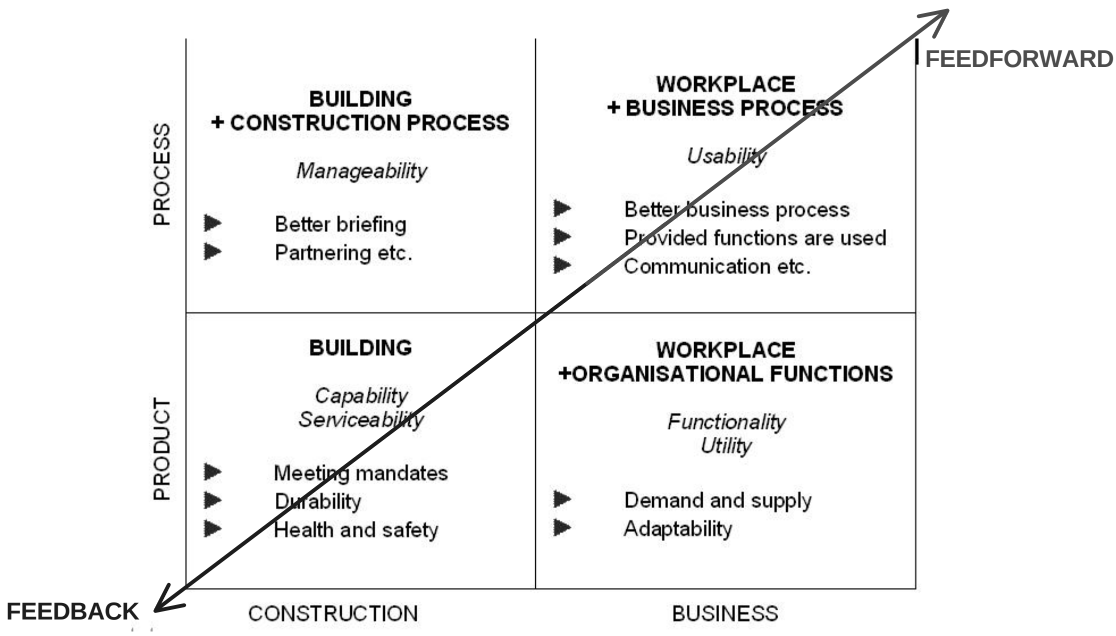

Figure 2: Approaches to workplace performance measurement

Feedback- Feedforward

It is also proposed that there is a fifth dimension to the approaches presented above: By evaluating the usefulness (of provided functionality) as in the approach 4, the knowledge gained is specific to that organisation and thus the nature of the feedback is to feed it forward to the development of processes and strategies within that organisation. Conversely, the assessment of the building from the physical point of view (approach 1) tends to provide feedback that is most useful for the construction industry. Thus, more focus should be placed on identifying how the business could benefit from evaluating the different elements of a workplace. Whereas assessing functionality aims at improving the physical product (workplace), usability aims at improving the business processes through better understanding them and through evaluating how the provided functions are actually used. It is proposed that the latter approach (Business process / usability) is seen to benefit the organisation the most as the results of workplace performance measurement can be fed forward to the future management of the workplace.

4. WORKPLACE PERFORMANCE MEASUREMENT TOOLS

> **Research Question 2***: What tools and methods that aim to demonstrate value are currently documented in literature and used in practice and what do they actually measure?*

To provide a context to the gap analysis, an overview of different approaches to workplace performance measurement within the six case study organisations and eight identified measurement tools/methods[ii] documented in literature is to be provided. The tools and methods used in the case study companies are first discussed. An overall comparison of the identified approaches is discussed in the next section.

4.1 Tools/methods in practice

All of the case study organisations had some means of monitoring workplace performance - most commonly: meetings with business units, monitoring of occupancy costs and utilisation of space studies. Occupant surveys and similarly Post Occupancy Evaluations (POE) type of surveys had usually been undertaken only once. Table 1 summarises six approaches that were considered as tools/methods.

[ii] The term ‘tool’ in this study is referred as to a research/data collection tool/method rather than, what could be perceived as, a verified measurement tool. The selected *tools* for the appraisal include various research tools/methods under development, but also more verified tools (mainly used in consultancy) are taken under examination. Common to these is a questionnaire-based approach to evaluation.

Table 1: Summary of the approaches to measurement in practice (case studies)

Method/tools	**Approach**
Time utilisation studies	Focus is on meeting the business needs to reduce costs (A, E, F).
Satisfaction survey	Focus on getting feedback on physical elements of the building and the service delivery (F)
Workplace performance survey	Focus on defining what aspects within the (physical) workplace and support services hinder task completion. (A,B,C)
POE	Focus on reviewing whether mechanical systems work in the new building. (A)
	Aim to identify satisfaction with environmental conditions and physical elements of space – whether workplace meets the expectations. (B,C)
	Aiming to understand how the space support business aims and objectives and functional requirements (F)
Communication network analysis	Focus on identifying who communicates with who – how is knowledge distributed and what impact space layouts and workplace improvements have had on communication (F)
Walk-through	Aim to identify what improvements in the management of workplace could be made and if physical changes needed. (D)
	Checking the quality of service delivery. (E, C)

4.2 Tools/methods documented in literature

Eight tools and methods were identified from literature (Table 2). A characteristic common to all of these was the development of performance of workplaces. All of these tools and methods include an occupant questionnaire (mainly targeted at staff, but in some cases at senior management only) and some of them also include specialist observations and measurements of the building and the environmental conditions within. However, the focus is not specifically on a process or method of data collection used, nor placed on the specific questions asked, but in the basic principles of the surveys. This is to better understand what these tools are aiming to measure and whether they meet the criteria identified in literature and in practice (which they were not necessarily developed to meet), and to identify what has already been done and tested and what areas need to be concentrated on in the future development of measurement tools and processes.

Table 2 – Tools under investigation

Tool	Approach
1. Workplace utility survey [17]	To assess usefulness, through defining the difference between the expectations and perceptions of the building's users.
2. User based building performance appraisal survey [13]	Provision of office accommodation design/ quality characteristics (supply) measured against specific property requirements (demand)
3. Hierarchical analysis model (HAM) [18]	To recognize the confrontation between the supply and demand of a set of building attributes, by identifying what kind of activity or organization does the building intend to suit (supply), and what kind of resources, installation or localization must be considered to suit a certain activity or organization (demand).
4. Office Environment Survey – Building Use Studies [19]	To identify positive and negative relationships between indoor environmental factors and human productivity.
5. Building-in-Use Assessment [20]	To determine patterns on comfort and discomfort throughout the building based on users' experiences and perceptions (functional comfort) and to relate this to physical environmental elements (such as floor layout differences, type of workstations etc)
6. Office productivity survey [21]	Matching facilities and building services to the specific business needs of the different departments within the building, through defining downtime factors, satisfaction and self-assessment of productivity. Defining the elements of the physical environment and how they can enhance or hinder performance.
7. The Serviceability Tools & Methods (ST&M)[22]	To specify the performance requirements for facilities, and to measure how well a design proposal, or an existing facility meets those requirements.
8. Workplace innovation Survey [23]	To enable analysis of the impact new workplace environments have on the performance (productivity, quality, flexibility and innovation) of organisations accommodated in these concepts, and to gain insight in the effects of technical, economical, social and organisational developments on the workplace.

5. GAP ANALYSIS

Research question 3*: How do these tools meet the set theoretical and practical requirements identified?*

The gap analysis is formed by evaluating the introduced tools (used in practice and documented in literature) against the proposed criteria (Figure 2). Thus, the provided matrix is updated to illustrate the current and proposed approach to workplace performance measurement through placing the introduced approaches onto this matrix according to the following aspects:

- To what extent have the organisational requirements been considered? Have they been considered from the point of view of space provision (functionality) or from the point of view of the actual support the space provides for business processes (usability)?

- Is the focus on improving the physical elements of the building (capability and functionality), on the process of constructing/ managing the building (manageability), or on improving the business processes (usability)?
- Is the main aim to collect information to feed back to the construction industry on their processes or products, or to feed forward to the business to enable the development of processes and strategies within their workplace provision?

As a result of this exercise, the demonstration of the gap between the current approaches and the proposed approach was enabled, as illustrated in figure 3 (blue circles illustrate the studied approaches and red the proposed target).

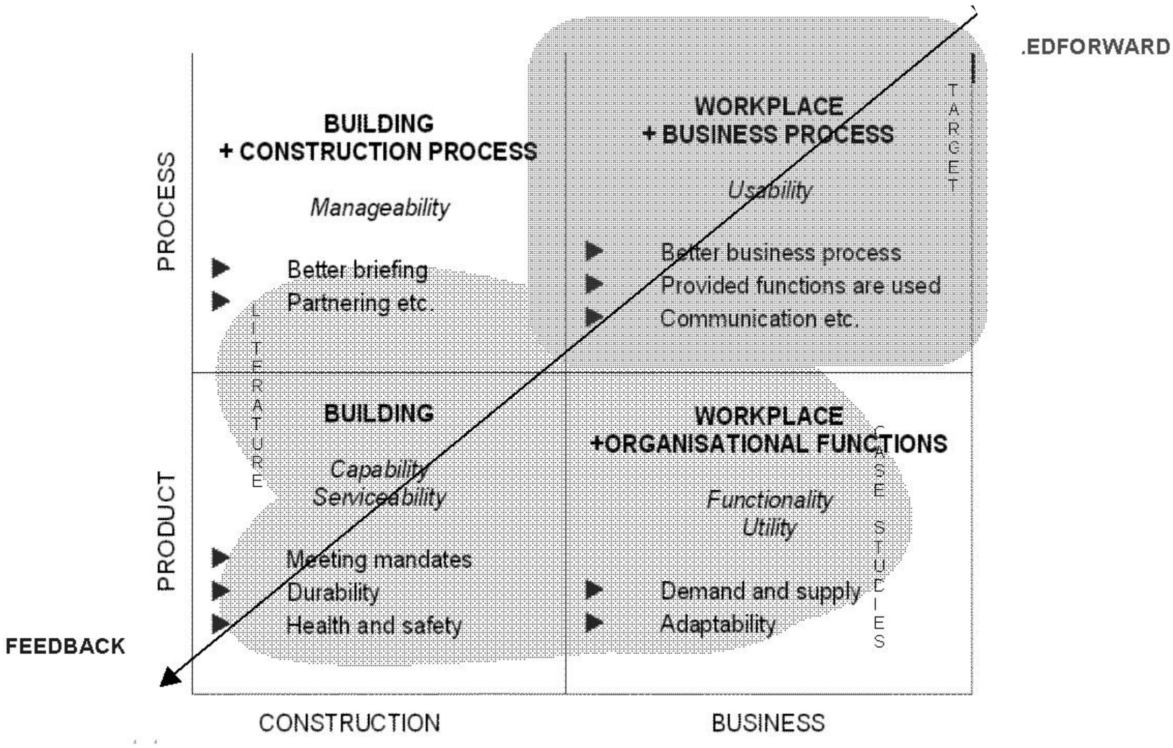

Figure 3: Gap between proposed and identified approaches

Thus it is proposed that there are no appropriate tools and methods identified for demonstrating the business value through workplaces. The following key reasons to justify this emerged:

1) Approaches focus mainly on providing feedback on the qualities of the workplace ‘product’ for the construction industry, thus little emphasis is placed on collecting information to support the continuous change within organisations (feedforward).
2) Focus is mainly on improving the physical workplace rather than the efficiency of the business processes – measuring the product rather than measuring the *effects* of the product.
3) An understanding of people activities, such as communication and team interaction that support business processes was underdeveloped.
4) The focus was mainly on defining the performance of a physical workplace, rather than the effects this has on the people activities.

6. Conclusions

As it has been emphasised, the workplace performance measurement should, instead of viewing workplaces purely from a functionality point of view (assuming that if the space supports the business functions it is useful), the usefulness of the workplace in use, during the activities, should be evaluated. Usefulness, learnability and ease of use were some of the qualities to be promoted. The aim should be to evaluate the effect of the workplace on the activities. By evaluating the usefulness of functionality, the knowledge gained is specific to that organisation and thus the nature of the feedback is to feed it forward to the development of processes and strategies within that organisation.

It is believed that the selection of tools that were documented in literature is fairly representative within the different UK approaches, but further investigation (prior to this thesis) is needed to confirm this i.e. an up-to-the-minute review of literature and other available material needs to be carried out. The scope could also be extended to an international level to identify whether different approaches have been taken elsewhere, for example, during the course of the study the authors have become aware of US based research that has established links between workplace design and job performance, job satisfaction and communication [24].

Less focus was placed on defining the processes of measurement as to who participates, when they are undertaken, how exactly they are carried out (reliability and thoroughness) and also 'by whom' and 'for whom' they are carried out. The impact of these elements needs to be further investigated.

The timing of the assessments and the replication of these, for example, are important areas of investigation, this, in turn, places importance on both the planning and design processes and on the on-going management processes. This enables the aims businesses set for new workplace settings to be reviewed and whether they have assessed the success of the outcome; but also whether there are/have been assessments of on-going (changing) business aims and any integration of these into the workplace settings.

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Delivery of Council and Community Facilities: Implementing a Stakeholder Process Model

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Abstract

In this Melbourne local government area the proposed library-community centre was the largest construction project ever attempted by the Council (A$8 million). This project incorporated innovative briefing methods through the use of a performance brief, which was developed and agreed with a range of stakeholders. This work focuses on the interactions, activities and processes following the initial development of the performance brief.

The study examines the processes used by the Council managers as a provider and developer (client) of the facility on behalf of its rate paying public. Recording and analysis of the processes captured the organisational learning that occurred during delivery of the project. The learning outcome is a model for future practice to guide this Council and other similar community based projects.

Research data gathering has included review workshops, interviews with project team members, attendance at consultations with community facility user groups, analysis of Council project documents and other Council documents. Analysis has been by means of a qualitative methodology analysing the textual materials with coding and time-event mapping techniques to identify key events and themes.

The project has provided sound lessons in strategic connectivity with organisational and Council strategies, the inclusion of a range of stakeholder interactions and consultations of real benefit to the value of the project, the use of innovative performance briefing methods and identifying the characteristics of an informed and engaged client. The study synthesises the key aspects of the project into a normative community based project model that represents the lessons learnt in the delivery of this library- community centre.

Keywords: design management, community interaction, project processes.

1. Introduction

The importance of including stakeholders in project processes is being increasingly recognized as important in delivering satisfactory project outcomes (Gray, et al, 1994; Kamara and Anumba, 2001). This is despite Walker's (2002) observation about 'unreliability' in stakeholder assessments across project lives. It is possible that part of this unreliability arises from not adequately engaging with and binding stakeholders into project processes from early stages.

This paper builds on earlier work by one of the authors into processes at project inception (Smith 2002) by examining the implementation of a stakeholder approach throughout pre-construction processes. The project examined is an *Urban Village* Library-Community Centre and originated from an external review by one of the authors of the processes designed and implemented by Council in delivering this important project. The Library-Community Centre is the largest construction project undertaken by this municipality (a middle suburban local government in Melbourne) with construction expected to be completed in mid-2005.

This paper is divided into three major parts as follows:

1. an identification of the most significant processes used in delivering the project including strategic connectivity;
2. an examination of the role of clients in construction projects and how the municipality has acted as a client in this project. This includes consideration of the interactions (including, but not exclusively, consultation) involved in delivery of the project; and
3. the 'Glen Eira Model' of project delivery processes is presented as a model process consolidating the lessons from this project as a guide for future local government facility projects.

2. Data collection and analysis

A variety of data collection methods have been used in the course of these reviews. These include:

- Review Workshop with Council stakeholders in March 2004;
- Interviews with project team members;
- Attendance at consultations with community facility user groups;
- Analysis of Council's project documents;
- Analysis of other Council documents such as Council meeting minutes, and municipal newsletters; and
- Analysis of local newspaper articles.

These data collection methods are in addition to those used by project team members during the project. Analysis has been by means of a qualitative methodology analysing the textual materials using coding techniques to identify key events and themes. Green (1996) describes this methodology as a Naturalistic Enquiry and notes it is overlooked in, yet is of importance to, research in the management of the built environment (in Green's case – construction management, but equally applicable here).

3. Processes to date

The four key processes identified in this review are:

1. **Strategic development** consisting of five strategies – two organisational and three municipal[1].
    a. Organisational – Service delivery (primarily Library, elderly citizens, and child care) and a Corporate Real Estate (CRE) strategy that matches the property portfolio better with organisational strategic aims; and
    b. Municipal:
        i. Local business development through support of threatened sub-regional strip shopping centres (Urban Villages strategy); and
        ii. Strategic Land-use planning (Urban Villages Strategy).
        iii. Community development through renewal of several community support assets.

    The development of the Council's Urban Villages Strategy was conducted in parallel to the development of its Library Strategy.

2. Council stakeholder **Strategic Needs Analysis Workshops** (Smith and Jackson 2000, Smith et al. 2004) in May and August 2000 has had several consequences:
    a. Strategic alignment between facility objectives and Council strategy;
    b. Council stakeholder 'buy-in'; and
    c. The generation of a *Performance Brief* used, in conjunction with an *Indicative Functional Brief*[2] to guide the project and in selection of the project consultant team.

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[1] Municipality is taken as the administrative area and its population, whereas the Organisation is the Council with its governing, administrative, managerial and service delivery functions.

[2] Performance-based briefs are thought to encourage innovative solutions to meet client needs and objectives and are framed as statements of required performance against project outcomes. Performance-based briefs may not contain, for building projects, definitive statements of functions and their requisite areas that are to be included in the building. Such definitiveness is more the domain of Functional Briefs. The use of an indicative functional brief established latitude that required negotiation within the stipulated performance parameters.

The client representatives commend the approach for its ability to negotiate the removal of sectional and political interests and any preoccupation with project minutiae by concentrating on the big 'picture

3. **Project's consultant team selection and appointment** consisting of consultant team Registration of Interest (ROI), short-listing and interview, and inspection of nominated architectural projects prior to final selection. The capacity to conduct community consultations was a key selection criterion.
4. **Consultation** has been a feature of this Library-Community Centre project with several consultative processes, both in the project itself and in the preceding Urban Villages Strategy which provided the siting rationale. Consultation is discussed further, below, in Interaction Processes.

4. Linking to strategy & strategic outcomes

Strategic planning and connection to organisational and municipal strategies are important features of this process. Of particular relevance are the Urban Village strategy and the planning amendments that followed these early stage developments. Community Consultative Committees for each of the Urban Villages made up of Councillors and community representatives were used during preparation of the Urban Villages strategy, commencing in 1997 (City of Glen Eira 1999) up until the adoption of the Urban Village Structure Plan in July 1999. Subsequently, amendments were made to the municipal Planning Scheme to incorporate the Urban Villages concept into the Planning Scheme requiring further consultation required by State Government legislation. The Library-Community Centre project specific consultations starting in late 2001 benefited from the previous consultation processes as they followed soon after these Planning activities in a roughly contiguous process spanning 4 to 5 years.

Assessments to date show that the proposed Library-Community Centre plan meets the five Council strategies identified earlier. It is both a supporter of community support policy (*a heart of the village*) and as a driver of change (catalysing behaviour change) and land use commensurate with the Urban Village concept. There are indications of anticipated positive behaviour change by municipal residents that is expected from and intended to be gained from the project.

5. Role of Council as a client

It is not unusual for construction projects to have several sub-clients each with an interest in the project outcomes (Walker 2002, p87-89). These sub-clients may, variously, have formal decision-making and governance roles, or roles as nominated client project representative, or champion, or as users. In this project, as for all local government projects, there are five sub-client groups, or clusters of groups (also called stakeholders). However, it should be noted that where an external funding authority exists, such as state or federal (central) governments, a sixth group would be added to the list.

1. Council (as Councillors). The group with formal legislative authority as decision-makers and holders of governance responsibility.

2. Council (as Council officers). The cluster of groups with a role as client representatives responsible for the project's day-to-day management and administration. This cluster includes a nominated project representative (Manager Corporate Assets in this project) as well as Council officers from stakeholder groups within Council. Such groups with a service delivery interest in the completed facility are the recipients of 'Internality effects' from the facility, being the effect the facility has on their operations[3].
3. Facility users from the community (as part of the municipality). Members of this cluster are also recipients of 'Internality effects' from the facility as a direct consequence of their use of the facility.
4. Neighbours (as part of the municipality). This group are the recipients of 'Externality effects' that are the impacts that flow outwards from a facility as a consequence of siting in a particular location.
5. Municipality (as a whole). Frequently styled as 'community', municipality is the preferred terminology as community is a contended term (Gibson and Cameron 2001)[4]. Also the recipient of 'Externality effects,' which are more diffuse in impact when considered at this level of generality.

The project's Council officer managers have been aware of these client groups and have incorporated interactions with them in the course of the project, particularly levels 2, 3 and 4 above.

6. An informed client

One of the key features of this project's delivery is how the Council has acted as an *informed* client in the project delivery process. In this project, Council, as client, has been highly motivated through awareness of the project's importance to Council and the municipality[5]. In addition to being informed about Council's client role, discussed above, the Council officers demonstrated informedness about:

- Their individual service;
- The combined overall Library-Community Centre facility;
- The synergies derived from the combination of services onto a single site;
- The Urban Design and Urban Planning context; and
- Site constraints and opportunities.

[3] Facilities, for the purpose of this discussion, are a conflation of the physical entity (building) and service delivery from that physical entity (Building + service) as defined by Brackertz & Pontikis (2000) + site + context, be that physical context (neighbourhood), and political, social and psychological contexts.

[4] There are two main categories of community. Firstly, there is a 'community of place' that assumes a consensual harmonious view where differences are ignored through an emphasis on common territorial or spatial interests (Saunders (1979); Martin (1998); and Lowndes et al. (2001)). The second is a 'community of interest' where a common stake creates a specific grouping (Martin (1998); Lowndes, et al. (2001)) .

[5] The metaphor 'Jewel in the Crown' was invoked more than once.

Being informed may derive from being an *experienced constructor* ((Walker 2002) citing (Masterman and Gameson 1994)). Local government, while experienced in construction, builds each type of facility infrequently which erodes assumed experience levels. To increase that experience level requires research and other informing processes during the project processes.

Research and informing is infrequently or poorly done by clients, drawing instead on their stock of 'lived' experience of the built environment (and in particular – facilities in this instance). This is risky as that the experience may be flawed being based on exposure to poor facilities (which may be the reason for them being replaced), or on facility and building types unlike those that constitute the project. In this project research at service delivery level occurred through review of work practices, consultant advisors on occupational health and safety, and inspection of exemplars.

The exposure key client groups – Council officers and Councillors – to exemplar projects, both positive and negative has had important consequences in attaining levels of informedness. The exemplars have been at the levels of the constituent facilities, such as Library, Child care, Community centre, and urban development projects where Council properties were key constituents in contributing to and leveraging urban development projects providing Council's desired outcomes. The latter investigations occurred at an early stage with Councillors and Council executives (decision-makers and influencers of decisions) participating. Exemplars were also used in interactions with facility users as part of an educative, expectation adjusting process.

A subtle, but important, part of this examination of exemplars is not using them as a model that may be copied directly to the project, but through suggestions that the new Library-Community Centre 'May be like this,' or 'This is similar to an outcome that this project may produce,' or enquiring 'How does this work?' The exemplars acted an 'inspiration' – in a mind opening sense, as there were positive and negative ones.

The use of exemplars in this way has, at least, two effects. Firstly, it focuses on outcomes from facility delivery processes rather than purely the physical product or environment. Outcomes may be service delivery, social, community support and development, urban development or similar. Secondly, it evokes affective type evaluations[6] which at the most global level are of the form 'We/I like/do not like ….' Or, 'We wouldn't want that.' Comments of this ilk certainly emerged from the data relating to exemplars.

Overall, this 'informedness' has contributed to an exemplary process that may act as a model for future project processes. This process is summarized later in the paper.

[6] Affect is a general class of psychological processes (Affect, Cognition and Behaviour) that include feelings, emotions, moods and similar aspect of beliefs, values and attitudes (Amedeo, D. (1993)).

7. Interaction processes

The Urban Village Library-Community Centre project can be characterised by the high level of consultation that has occurred in the project's Planning and Design phases. Review of the literature during the course of this research revealed a range of possible ways of engaging with project stakeholder and community groups.

The term 'Interactions' was preferred to 'Consultations' as the authors consider interactions in management consist of more than consultation, including a range of possible management activities used in achieving project ends which may include meetings, data gathering and decision-making interactions. Unfortunately, limitations of space prevent a detailed discussion of the types of interactions, but (Heywood et al. 2002) propose a typology of interaction practices in a local government context.

The municipality's CEO noted at a Community Forum in May 2001 that this Council used at least 15 consultation (interactions) methods in its activities. Some of these are legislated in Planning or Best Value requirements, and some are not applicable to project delivery. For example, elections, and the focus groups and telephone survey interviews operate only in a more general sense as part of setting and confirming organisational priorities and agendas through research.

8. Types of interactions

It was important to have appropriate interactions occurring at times of maximum advantage to the project's delivery. The project benefited from its links with the Urban Villages strategy and their Urban Planning interactions. Within the project there have been several timely types of interactions, including:

- The use of Strategic Needs Analysis Workshop leading to the preparation and agreement of the content of a *Performance Brief*;
- Research by Council officers into the constituent facilities (use of exemplars), and review of current work practices, and the like (as noted above).
- Data gathering and brief building interviews (individual and group) by the project consultant team at the commencement of the Design phase. This provided necessary, specific information from the project's sub-client groups;
- Project Control Group meetings continuously (approximately fortnightly) throughout the Design phase made up of design team members and Council stakeholders;
- First Community Review and Input Consultation with responses from the round of interviews evident;
- Subsequent rounds of Community Review and Input Consultation at the end of stages and precluding subsequent stages;

- Linking with Public Relations releases by Council at the commencement of project stages;
- Important, in terms of project governance, are approval interactions at stage ends both with Councillors and PCG; and
- While it is still to occur, a review approximately 6 months following occupation would be another possible interaction.

The content of consultations was important. Initially the design team relied on 'Asking' and 'Listening' type interactions in the data gathering and brief building; that is listening without having explicit, concrete requirements already set[7]. Consultations of this form were a requirement of the project's performance briefing approach as definitive functional statements were not provided initially but which required negotiation achieved in this project through:

- The early use of design drawings to respond to the briefing information provided; and
- The Project Control Group (PCG) meetings noted above.

In this process data gathering was not on the basis of 'Tell us how much space you need,'[8] but rather on the basis of, 'Tell us what you do in your spaces.' The dimensions of existing spaces were ascertained from facilities' existing conditions drawings. This approach had several benefits for the project as it utilised:

- The workplace activity and service delivery knowledge from Council officers;
- The activity basis knowledge of users; and
- Architect's integrative capacity and expertise in spatial matters in 'design'.

Several benefits flowed from this approach. Firstly, it avoided the premature fixing of space demands acting as a 'circuit-breaker' between existing space occupied and that to be provided in the new facility. Secondly, in capturing the activity knowledge of facility users and service providers the spatial consequences of those could be ascertained by experts in building spatial matters (architects and the like). And, thirdly, this listening data gathering process utilised the integrative capacity of architects in 'design' to translate the received information into design solutions that responded to the *Performance Brief*, information received in consultation[9].

Evidence of this 'listening' approach was apparent in the presentations by the design team to the Community Review and Input Consultations. It was noted that they always referred to the points that the particular group had mentioned as important to them in previous interactions. Major benefits of this approach have been stakeholder buy-in (a psychological commitment and ownership of the project) from the earliest phases of the project and the achievement of high

[7] It should be noted that Council officers had conceptualised where the project might go as a result of the Strategic Needs Analysis and performance briefing, without necessarily pre-empting input from consultees and project consultants.

[8] This approach is often used to construct functional briefs.

[9] Which were considerable, being an elongated rectangular site located between and interfacing with both a residential area and a sub-regional strip shopping centre.

satisfaction levels now noted as being expressed by community groups and have been so from the earliest parts of the Design phase.

9. Project reviews

Project reviews have consisted of Schematic and Design Development reports from the design team for sign-off by the Council before proceeding to further project stages. Formal review meetings were not conducted to assess achievement of the Briefs (Performance and Indicative Functional)[10]. Rather, continuous review through the Project Control Group meetings and the Schematic and Design Development reports sign-off achieved much the same effect.

At the completion of Schematics Stage and before Design Development commenced a series of one-on-one internal review meetings between the Manager Corporate Assets and Council client groups assessed design and brief status.

Finally, the Review Workshop that examined processes used in delivery of the project to encapsulated the organisational learning to date and acted as a transmission of project history and learning following staff turnover during the project.

10. Project overview

10.1 Satisfaction with project processes

A high degree of satisfaction has been expressed with the project and project delivery processes to date. ‘Happiness’ and ‘pleased’ are frequently reported responses from individuals and groups participating in project interactions.

The satisfaction of project participants is based more on the fact that they were consulted, rather than what they saw as important was being included in the project; and seen as important by the project team; certainly in the emphasis given to these important items in reporting back to project participants.

10.2 Criticisms with the project processes

Given the satisfactions noted above and the positive reporting of project processes in this paper, it would be anticipated that there were few criticisms to date. This is the case. Criticisms coalesce around two points. The most minor of these is some of the arrangements for

[10] Note that the term, *achievement* is preferable to *compliance*, which does not fit the concepts of performance in the performance briefing approach used in this project.

consultations could have been better. The more important point that received more criticism was related to project delays.

From the elderly citizens came a telling and poignant critique of the project delays. Having contributed to making the project processes successful, thus far, there were speculations whether they would live long enough to have their efforts rewarded in seeing the new Library-Community Centre open.

Project delays could be attributed to three causes. Firstly, ‘political’ reasons which would be linked, in the main, to matching organisational funding requirements. Secondly, the compulsory acquisition of adjoining properties, which took time to resolve. Thirdly, that all of the project’s Urban Planning requirements were not made clear enough early in the project enabling all the project requirements to be dealt with in a single planning application process. It should be noted that this criticism is one that is frequently made by many sponsors of development projects in both private and public sectors.

11. The ‘Glen Eira Model’

To date, the project delivery process for the Urban Village Library-Community Centre has been exemplary through the strategic connectivity achieved, the inclusion of a range of interactions of real benefit to the project, the use of innovative performance briefing methods, and an informed, engaged client across the levels of sub-client. These characteristics have all contributed to the derivation of positive project outcomes.

Given the success thus far, it is possible to condense out key aspects of the project delivery into a normative community based model – ‘The Glen Eira Model.’ The Model is a representation of the lessons learnt in the delivery of this Library-Community Centre, and as a model process may be used to guide other local government facility projects. The important first part of the process the strategic management component of the model is summarised in Figure 1, below. However, in its entirety the model and process contains three connected streams as follows with the significant features noted:

Stream 1 – Strategic

- Strategic connectivity;
- Service delivery strategies with requirements for a built environment;
- *Strategic Needs Analysis* Workshop and creation of a *Performance Brief;*
- All possible Council stakeholders invited and present, and
- Output – Performance brief and indicative functional brief.

Stream 2 – Informing

- Informing via exemplars;

- Types of questions asked of exemplars, and
- Building knowledge as a basis for detailed briefing.

Stream 3 – Design management

- Use of performance brief;
- Consultant selection that was responsive and with a consultative track-record;
- Project Control Group with all possible Council stakeholders participating;
- Brief building through:
    - interviews with all possible stakeholders, and
    - Community groups' interviews
- Consideration and inclusion of recipients of 'Externality' and 'Internality' effects from the new facility in project processes;
- Early use of drawings, particularly 3-dimensional ones in consultation;
- Use of tactical Public Relations;
- Iterative/feedback reviews/consultations with stakeholder Community groups, and
- Review to confirm achievement of Performance Brief objectives.

12. Conclusion

The project delivery processes for this Urban Village Library-Community Centre has been an exemplary implementation of a stakeholder approach to project delivery. Lessons that may be taken from this study include:

- High levels of strategic connectivity showing relevance to and of Council stakeholder strategies;
- Client (as project delivery manager) awareness and engagement with client sub-groups identified (stakeholders);
- Development of client informedness through research and access to exemplars by client sub-groups;
- Deep and contiguous[11] interactions with stakeholders throughout project processes;
- Content of interactions is important, particularly the form of questions asked; and
- Development of a normative model encapsulating organizational learning from this project.

[11] Contiguity is suggested as a form of connecting content from one interaction to the next.

13. Acknowledgements

The authors wish to acknowledge the Australian Research Council, and the City of Glen Eira for their financial and strategic support for this project.

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Appendix

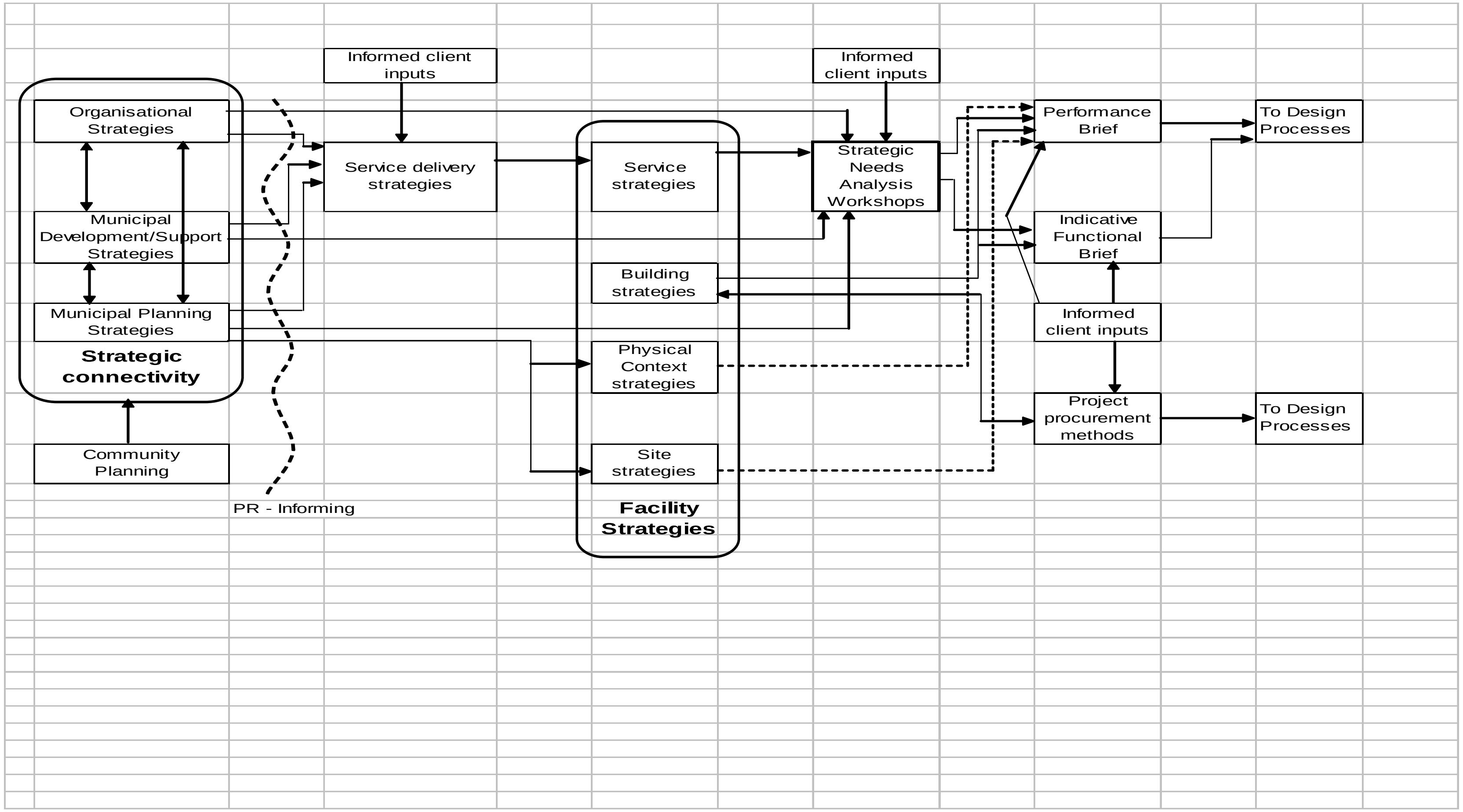

Figure 1 Strategy Stream

Section II

Emerging new FM aspects

The strategic impact of managing risk with high performance, high cost shopping centres

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Abstract

This research paper compares and contrasts the risk management approach adopted by a major public sector operator of shopping centres in Hong Kong with those managed by the private sector. By adopting a structured survey, the paper establishes 'risk items' identified by the public sector organization; the response by the organization to these risk items; and a comparison with their response to that of the private sector. Survey results indicate that managing risk in shopping centres is complex, where relatively small disorders can create a significant impact on a centres' successful operation. The survey also revealed that the public sector operator's risk assessment awareness was weak, generally focusing on emergency guidelines for previously known, identified risk items. In addition, public sector response to risk was determined to be overly bureaucratic, with a potential for crises to degenerate to a disaster. This may be contrasted with the private sectors whereby risk is, by and large, proactively managed through active avoidance measures, risk reduction and risk transfer. The paper concludes by recommending a facility management response to managing risk for public sector shopping centres.

Keywords: Risk management, shopping centres, comparative survey, public / private sector

1. Introduction

"*When the going gets tough, the tough go shopping*", Anon.

Hong Kong is home to seven million inhabitants, and the city's tourism board expects the tally for tourist arrivals in 2004 to exceed 21.4 million, a record for Hong Kong. The city prides itself as a "*shopper's paradise*", a theme trumpeted loudly by the Hong Kong Tourist Authority. Sceptics may wonder at the veracity of this notion, yet few would deny that shopping in Hong Kong is a serious business. Locals and visitors alike have a wide choice of shopping venues, from the hustle and bustle of Causeway Bay on Hong Kong Island, with its cluster of Japanese department stores, dense street side markets stalls and more recent up market exclusive designer label shopping emporiums. Kowloon-side also offers a similar range of traditional shopping experiences among the environs of Nathan Road, Temple Street and Canton Road. During the last twenty years Hong Kong has also added the ubiquitous shopping centre, from the prosaic out of town "*local*" shopping arcade with its Chinese wet market, government offices and retail outlets to amazingly glitzy malls that provide both entertainment thrills as well as retail therapy. On Sundays and festive holidays these venues often arrange promotional activities to attract visitors, and it is not uncommon for the serious shopper to have to weave around these watching crowds in order to continue their hunt for bargains, exclusivity or the merely fashionable. Under these circumstances, shoppers are probably more mindful of the risk to their wallet than their physical security, assuming that risk, in whatever form, is being managed "*behind the scene*" by trained property managers whose skills and knowledge are sufficient to deal with all eventualities. This naïve assumption is perhaps understandable, for few untoward occurrences have (publicly at least) taken place among Hong Kong's shopping centres during the last few years. Nevertheless, the public has a right to demand at the very least that those who manage facilities are aware of potential risks, and have contingency plans to ameliorate crisis or disasters from occurring.

1.1 Risk Management

Risk management is the process of measuring, or assessing risk and then developing strategies to manage the risk. Ideally, risks with the greatest loss and the greatest probability of a risk occurring are dealt with first, and risks with a lower probability of occurrence and potential lower loss are dealt with later. Unfortunately balancing the likelihood of an event occurring against its potential loss is extremely difficult, and property managers charged with maintaining shopping centres frequently face difficulties that extend beyond their built fabric. For example, shopping centres, similar to other buildings that accommodate public space, typically bring together relatively large numbers of people (shoppers) whose knowledge of the facilities is low. These shoppers may be first time, or infrequent visitors whose general awareness of the centre construction, layout, safety features or safety personnel is generally weak. Shopping centre design attempts to mitigate potential hazards by imposing restrictive building codes and regulations, particularly those related to fire safety. Even so, without effective property management, architectural good practice can be frustrated by uncaring or ignorant behaviour, [1].

The UK's MI5 Security Services [2] has recently published a guide for protecting assets. Although focused on terrorism, the guide offers a general review of managing risk. The guide adopts an integrative approach, highlighting four main issues, i.e. 1) identify the threats; 2) establish what you want to protect and your vulnerabilities; 3) identify measures to reduce risk (security improvements / plans; and 4) review security measures and rehearse / review security plans. The singularity of the guide highlights the times that we live in, albeit to date the threat is more in the imagination than the execution. However, being prepared for eventualities is the hallmark of good risk management and the guide offers excellent advice. For example, is there anything about a shopping centre, staff or its activities that would attract (in this case) terrorist attack? It also questions whether the centre's location would mean that it may suffer collateral damage from an attack on a high risk neighbour. (Given Hong Kong's proclivity for mixed use commercial development, blending shopping malls and high rise office space with hotel and serviced apartment accommodation, this latter scenario is more likely.) The guide's advice on what to protect is instructive with its focus on people (staff, customers, visitors and contractors);

physical assets (building fabric and contents); information (electronic and non-electronic data); and processes (supply chains and critical procedures). People take top priority when assessing the consequence of risk, with other assets depending on the nature of the business. In the current context, shopping centre managers normally have well rehearsed contingency plans in case of fire and crime. In addition, the guide reminds shopping centre HAs that they should also have procedures for assessing the reliability and integrity of those they employ. This is an increasingly difficult and controversial issue, particularly in Hong Kong where contracting out of safety and security personnel is common. The MI5 Security Advice also highlights this point "*There is little point in investing in costly security measures if they can be easily undermined by a disaffected inside, or by a recruitment process that permits people wanting to cause harm to infiltrate the organization.*" Continuing, the guide continues by emphasizing the need to conduct regular reviews and rehearsals to ensure that security and safety plans remain accurate and workable, and take into account any temporary or permanent changes to both the physical assets (the shopping centre) of procedures (information and communication system, health and safety issues). The guide also emphasizes the role of vigilance among shop tenants, shoppers, visitors and contractors when confronting untoward events.

1.2 Risk preparedness

The Genesis for the study was a freak accident that occurred at one of Hong Kong's suburban shopping centres. A nine year boy fell through an unsecured glass balustrade resulting in serious head injuries. Fortunately he made a full recovery. An investigation instigated by the centre HA concluded that the original building contractor was liable for the accident. (The shopping centre was relatively new.) As a result the HA suspended the contractor's new project tendering rights for a period of six month. The decision initially closed the case. However, public misgivings lingered over the accident. For example, public opinion questioned why the HA had not monitored the construction work more diligently, or why at handover a thorough check of the centre had not found the problem. Knowing that the centre's day-to-day property management had been contracted out, they also questioned why this company had failed to undertake periodic inspections of the balustrade? These questions go well beyond simply knowing the technical cause for failure: they fundamentally question the existing design – construct – commission – operate paradigm. Knowing that each phase of the project is directed by competent professionals, the public's misgivings are understandable. Simply put "*who is responsible for checking as built systems and determining risk?*" "*Is risk awareness in shopping centres inadequate?*" "*Are current property management systems sufficiently flexible to deal with risk?*"

To answer these questions, a small scale research study was undertaken, [3]. The study adopted a three pronged approach. First, a literature review was undertaken. Second, a series of semi-structured interviews were conducted with shopping centre HA representatives and personnel. Interviewees represented both the public and private sector, including in-house and contracted out personnel. Interviewees represented mid-level managerial grades tasked with either overseeing property management contracts, or with direct day-to-day management issues. All shopping centres formed a part of Hong Kong's largest public sector housing authority's portfolio. Interviews were divided into two parts. The first part requested information pertaining to the interviewee’s organizational, management structure and their general awareness of risk within shopping centres. The second part reviewed their knowledge of the organization’s business continuity planning and management. During each interview supplementary questions explored the existing procurement, operation and maintenance systems, and inquired of the difficulties (if any) of implementing these systems. Thirdly, an observational record was conducted over a one year period. The last provided sufficient insight to verify that risk “*hazard, chance of bad consequences, loss etc, or exposure to mischance”*, OED, rarely occurred without some foreknowledge. Unfortunately the observational evidence indicated that these warnings were frequently overlooked or went unnoticed due to ignorance, negligence or sloth. The study also indicated that preparedness for risk appeared to be variable, with some centre managers uncertain whether problems had been caused by natural force, human error, deliberate damage or progressive deterioration.

1.4 Interactive complexity and tight coupling

Two identified factors or properties determine whether a potential danger is more “risky”, i.e. ‘interactive complexity’ or ‘tight coupling’ [4]. Interactive complexity describes the potential for unforeseen interactions to occur where complexities and interdependence of relevant factors are unpredictable. For example, the failure of a computerized building services system that causes the breakdown of other systems may eventually paralyze most other systems. Tight coupling describes rapid and uncontrolled propagation of undesired events due to failure. The process happens very fast and cannot be turned off until the failed parts are isolated. Complexity and coupling may also be interrelated. For example, locating building systems in too small a space with complicated access may lead to missed routine maintenance. In consequence, this may lead to possible difficulties in isolating failed components thus resulting in a potentially more widespread catastrophe. High system complexity also demands greater technical awareness among operation, maintenance and management personnel. Where these conditions apply, system buffers and redundancies, deliberately designed into the system, act as a safety feature. However, without an intrinsic understanding of system safety and reliability issues, catastrophic failure can easily occur.

2. Risk and diversity in shopping centre design

The Hong Kong Housing Authority (HA) owns 650,000 public rental flats, housing approximately two million people (about one-third of Hong Kong's population). To bring convenience to and cater for the daily needs of public housing tenants, the HA also builds shopping facilities in the vicinity of our estates.These centres provide retail, recreation and leisure, health and social functions, etc. The HA categorizes shopping centres into four distinct groups, i.e. District Centres, Greenfield Centres, Large Neighbourhood Centres and Small Neighbourhood Centres.

District Centres are characterized by their strategic location, typically adjacent to mass transport railway stations serving a comparatively large catchment's area. The level of retail provision is usually high, catering for both local and outsiders. District Centres typically support a population of 150,000. Major tenants include department stores, supermarkets, Chinese and western restaurants as well cinemas. Building service provision is high, with full HVAC, escalators and lifts. Greenfield Centres are 'first generation' shopping centres located in New Towns. These centres typically enjoy good business during the early years due to the absence of competition. However, as the New Town matures, the population increases and private sector development is encouraged Greenfield Centres face increasing competition. Consequently these centres are normally upgraded to a level similar to District Centres. Large Neighbourhood Centres are typically located within public housing complexes away from private sector housing. Typically, they serve a community of 25,000 to 50,000. Their primary market is nearby public housing tenants, although well managed centres have the potential to attract outside customers. Major tenants are usually at least one Chinese restaurant, supermarket, and fast food café. Neighbourhood Centres are limited to no more than three floors, with escalators providing vertical movement between floors. Usually these centres are located close to main roads and bus terminals. Small Neighbourhood Centres are small commercial centres serving communities with a population of 25,000 or less. Typically, these centres are single storey located on the ground floor of a multi-storey housing complex. Retail provision is limited to a supermarket, small wet market and a convenience store. Usage level is normally low due to keen competition in the vicinity and because there is little prospect of attracting outside patronage.

During the 1990s the management of these shopping centres changed from in-house to one where the majority were outsourced, or contracted out. Two separate schemes were adopted, i.e. Single Operator (SO) and Private Management Agents (PMA). The SO scheme aims to enhance shopping centre management standards by developing a close partnership with the HA and the SO. Under negotiated lease terms the SO operates, manages and maintains the whole centre for periods of six to nine years. The SO is allowed to sub-lease separate units in the centre to third parties, or licensees. In agreement with the HA, the SO is also permitted to make minor alterations and decorate the centre. The primary aim of the SO scheme was to harness private sector expertise in the management of the shopping centres, e.g. shop layout, trade mix and promotional activities, etc. At a secondary level, the scheme also had the advantage of redeploying shopping centre estate staff. Disengagement by the HA from day-to-day management also provided an opportunity for top management to deal with strategic issues, whilst withdrawing from tactical, day-to-day concerns. Under the SO scheme the HA performs the role of intelligent-client, concerned with establishing, reviewing and monitoring the SO contractor's performance and securing compliance of the contracts terms and agreements. However, once the SO scheme had been operating for a number of years a number of weaknesses appeared. For example, in some instances, the HA was unable to ensure that the SO delivered the best quality of services to the public. By forfeiting the right to select sub-leasers, the HA was also unable to influence or protect essential yet low margin retail outlets or public service facilities. Experience also indicated that at the conclusion of the lease major renovations to the shopping centre were unavoidable.

The Private Management Agent (PMA) scheme introduced in the late 1990s attempted to address some of the problems of the SO, particularly those concerning tenant mix. PMA contracts are normally for a two year period, with the right for an additional two year renewal. The PMA contractor is paid a fixed fee for services provided, and reimbursed for all costs incurred in connection with the operation and management of the centre, e.g. electricity, water, consumables. The duties of the PMA contractor are defined as: to collect revenue and other payments to the HA; to follow up delinquent payments; to enforce tenants' contractual obligations; to be responsible for all minor repair and maintenance of the building fabric and building services systems; to provide daily cleaning and security; to prevent illegal hawking; and lastly to plan, organize and coordinate promotional activities. On the other hand, the HA retained the right to handle all leasing matters and tenant selection; set rent levels and tenancy agreements; deal with tenancy renewals; act as final arbitrator between the PMA contractor and tenants; and monitor and assess PMA contractor performance.

The PMA scheme has been judged to be a success, with the majority of the HA's shopping centres now managed in this way. Nevertheless, during the research a number of HA representatives expressed concern at the relatively high turnover rate of PMA staff, with its attendant need to train and offer guidance to new PMA employees. They were also voiced disquiet about the unwillingness of some PMA contractors to deal with the public. For example, one representative stated that some PMA contractors were slow to respond to requests for repairs and maintenance, and that they lacked initiative with respect to environmental issues. He considered that, in this case, the PMA contractor lacked experience in handling the agent / tenant / customer interface. This is perhaps not unsurprising since pre-registration criteria for potential PMA contractors tends to emphasize property management skills, financial integrity and legal knowledge rather than customer services' skills. Further, observations indicated that PMA staff tended to rely heavily on the HA representative to handle sensitive public relations issues. Concern was also expressed that the PMA scheme created problems in communication and coordination between the HA representative and PMA staff. This may be a reflection of the potentially adversarial relationship between the HA representative and PMA contractor whereby performance standards are strictly enforced through legal interpretation of the contract specifications. This was also true for SO contracts, although one interviewee stated that poor performance of a PMA contractor might result in a warning letter; whereas a SO contractor may incur a financial penalty or possibly termination of contract.

Interviewees were also asked to identify risk elements related to their potential threat, expressed in terms of emergency, interruption, severity and frequency, tables 1 and 2.

Table 1: The relationship between emergency and interruption related to shopping centre risk, or threats.

Threats	Emergency			Interruption		
	Low	Medium	High	Low	Medium	High
Natural hazards		X			X	
Man-made errors		X		X		
Progress deterioration	X			X		
Deliberate damage	X				X	
BS system breakdown		X				X
Fire			X			X
Personal injury			X		X	
Renovation / improvement	X					X
Criminal activities			X		X	
Uncommon disaster			X			X

Table 2: The relationship between severity and frequency related to shopping centre risk, or threats.

Threats	Severity			Frequency		
	Low	Medium	High	Rare	Seldom	Often
Natural hazards		X			X	
Man-made errors	X					X
Progress deterioration		X				X
Deliberate damage		X			X	
BS system breakdown		X				X
Fire			X	X		
Personal injury		X				X
Renovation / improvement	X			X		
Criminal activities		X			X	
Uncommon disaster			X	X		

As the tables illustrate some risks are deemed to be more important than others, either due to their propensity to occur or severity of problems manifest from occurring. Interrelated but not assessed is the impact on business continuity in the event of a serious breakdown. Nevertheless, the two tables help to prioritize commitment and remind the centre managers of the most critical and important issues in operating the shopping centre, i.e. health & safety of the public, tenants and staff; maintenance of building services systems; and maintainability of business.

When asked to reflect on the most common emergency to occur within the shopping centres, the interviewees identified three issues, i.e. personal injury - slipping or falling; power outage; and flooding. Response to an emergency usually related to the availability of on-site resources, the experience of front line staff and written guidelines. However, SO / PMA staff criticized these guidelines, identifying a general lack of experience from those charged with drafting them. They also commented that these guidelines did not always clearly identify responsibilities. The respondents were asked to comment on their knowledge of risk planning. Most knew that emergency and safety plans existed but few could identify who within the organization constituted the emergency team or what backup or recovery systems existed. They were also unaware if a public relations strategy formed a part of emergency planning.

3. Conclusions

The study indicated that risk awareness was not linked to the management structure of the shopping centre, nor was it substantially impacted by whether the centre's management was in-house or contracted out. Nevertheless, a lack of contractual clarity in defining risk responsibility does seem to have had an impact. Additionally, because of the HA reliance on contracting out, with its attendant loss of control of on-site staffing, training, and quality control, securing the right contracting-out partner was considered to be essential. Unfortunately, guidance on the selection of SO or PMA organizations tended to emphasize cost targets, not quality, timeliness and good practice. Ultimately this approach may be said to be counter productive. Poorly trained, low waged and unmotivated personnel have limited capabilities for dealing with a crisis. What is needed are staff who can recognize an unfolding situation, instinctively knows how to react and well able to communicate the threat or risk to authority. If a security guard has to evacuate a shopping centre they need to have an understanding of how to do it, or at the very least they have the initiative / authority to make it happen.

The study also indicated that although senior management were cognizant of documented risk exposure, they were less certain on how to deal with unconventional problems. For example, during the interviews good practice relating to shoplifting and vandalism was discussed. However, no mention of the possibility for acts of terrorism was raised. In the context of Hong Kong this may be understandable since outside terrorist threats would appear to be minimal. However, shopping malls are increasingly raised as possible targets in both the US and Europe, [5]. Recent troubles in the Philippines, Indonesia and Thailand belittle Hong Kong's absence of concern. If such sentiments seem too alarmist it is only necessary to go back to Hong Kong circa 2003 to find evidence where, initially at least, risk preparedness was woefully lacking. From March to August 2003 Hong Kong was on high alert for the SARS virus, a virus that eventually killed 299 and infected almost 1800. The virus also had a severe impact on Hong Kong's economy. However, in the early days little was understood about the virus in terms of transmission. Consequently, shopping centres, intended to be friendly locations, were treated by customers as potential hazards. Restaurants, cinemas and many public venues were deserted and universities and schools closed. Shopping centre owners were alarmed at the prospect that their property would be associated with the SARS virus. Eventually, they went to enormous lengths to ensure that the risk of infection and contagion was minimized. However, in the beginning few had contingency plans to deal with the SARS crisis at the beginning. Gradually, operators introduced extensive SARS preventative measure, e.g. disinfecting common areas, lifts and entrances on an hourly basis; air-conditioning filter replacement rates increased; outdoor air intake increased as well when feasible natural ventilation was adopted. In an attempt to gain the approval of their tenants and their tenant's customers one Hong Kong private developer acted very quickly by issuing instructions to their centre management staff and security guards "*to be* *extra vigilant and actively monitor tenant activities….report any unusual occurrences to the Property Manager for them to confirm a potential change in the level of risk…..vacation of premises, changes to cleaning schedule of premises, request for additional ventilation or air filter cleaning, extensive wearing of face masks, and attendance of medical/ambulance personnel to the premises or rumours of an incidence of infection*.” By raising the company’s level of risk awareness the firm was assuring both employees and tenants that ‘*expecting the unexpected*’ was good risk management. They recognized that they needed to “*identify potential impacts that threaten an organization and provides a framework for building resilience with the capability of an effective response that safeguards the interest of its key stakeholders, reputation, and brand and value creating activities,* [6]. Under these circumstances effective public relations was seen to be as important as technical know how. The obvious lessons to be learnt from SARS is “expect the unexpected” and develop a comprehensive business continuity plan sufficient to include an effective emergency response, a workable contingency arrangement and a feasible recovery plan.

Postscript: Since the study was completed the HA has initiated a major scheme to bundle all shopping centres and car parks in a Real Estate Investment Trust, or REIT. The Link REIT is composed of the HA portfolio of 2.85 million sq. ft. of retail space and 59,000 commercial parking spots. The initial public offering is valued at almost US$2.7 billion, making it the largest REIT offering in history. It was expected to debut on Hong Kong's Hang Seng exchange December 2004 but due to legal issues the launch has now been delayed. However, the Hong Kong Government is confident that the Link REIT will eventually go ahead.

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Parking Storage Planning and Facility Installation in Buildings

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Abstract

Increasing the prosperous economy and national income, a convenient lifestyle needs more automobiles. According to the Government of Taipei statistics, the metropolis owns 62,536 chargeable parking spaces and 670,999 vehicles registered in Taipei, indicating that approximately 11 cars share a single parking space. This fact means that existing parking spaces are not enough to accommodate the number of automobiles. Upon integration into the international free economy and entry into the WTO, a suggestion is to reduce import duty on automobiles. This way leads to a rapid surge in the purchasing of automobiles and an increase in parking space demands. Meanwhile, in Taiwan's previous development plans, no parking spaces were set-aside in the downtown area of Taipei. The ideal areas in downtown feature high costs, are difficult to acquire and the amount of traditional ramp or flat parking spaces are not effectively adequate. In view of that, large-scale construction corporations have cooperated with Japanese experienced parking facility manufacturers to solve the problem and create new business opportunities. The latest automatic mechanical parking storage facilities provide much needed parking space and make the multi-sectional parking facility attached to main buildings a standard. This results in new opportunities for the construction industry.

Keywords: Parking storage, park, facility, car

1. Introduction

Current macroeconomic distress has resulted in a downturn for the entire building industry and the price of real estate also dropped significantly. Therefore, hard-won parking spaces are more popular and prominent. The series of products launched by construction corporations, combined with parking space storage, provide households who originally possessed cars with parking spaces, as well as additional income for office buildings. This fact obviously proves that there would be more common scenario in the future real estate market. Nevertheless, this breakthrough would bring about quite different and new circumstances to the space of the architecture itself, and also construction cost and environment. This study intends to provide useful information, for attracting potential purchasers and new ideas will be presented for investors.

2. Literature Review of Parking Storage Facility

The "Advanced Storage" fully automatic parking system, also called the "Large-Scale Plane Reciprocating System" in the Norm of Type Determination by Japan's Ministry of the Economy, mainly consists of tower and underground storage systems in Taiwan. The basic movements are as Figure 1.

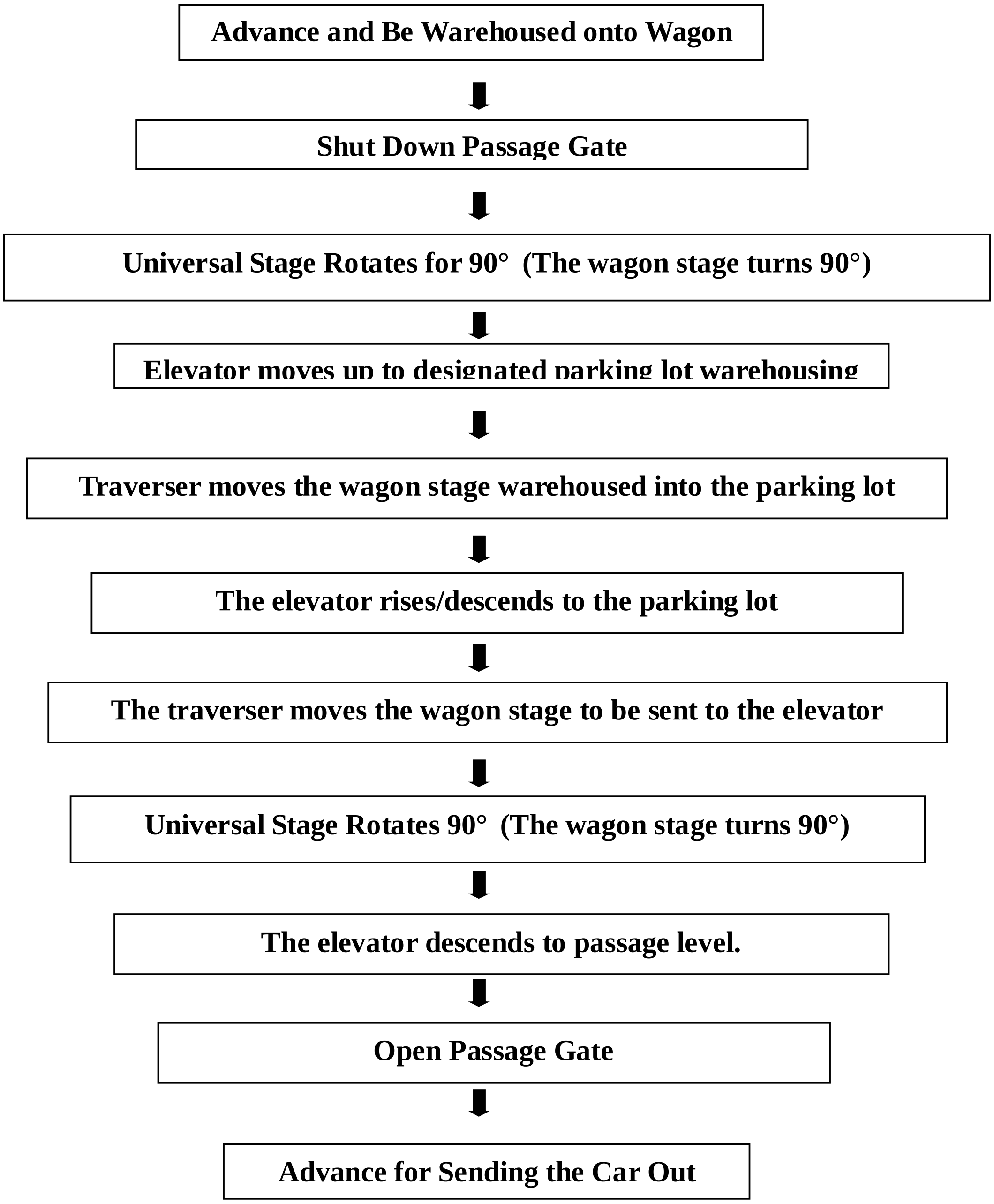
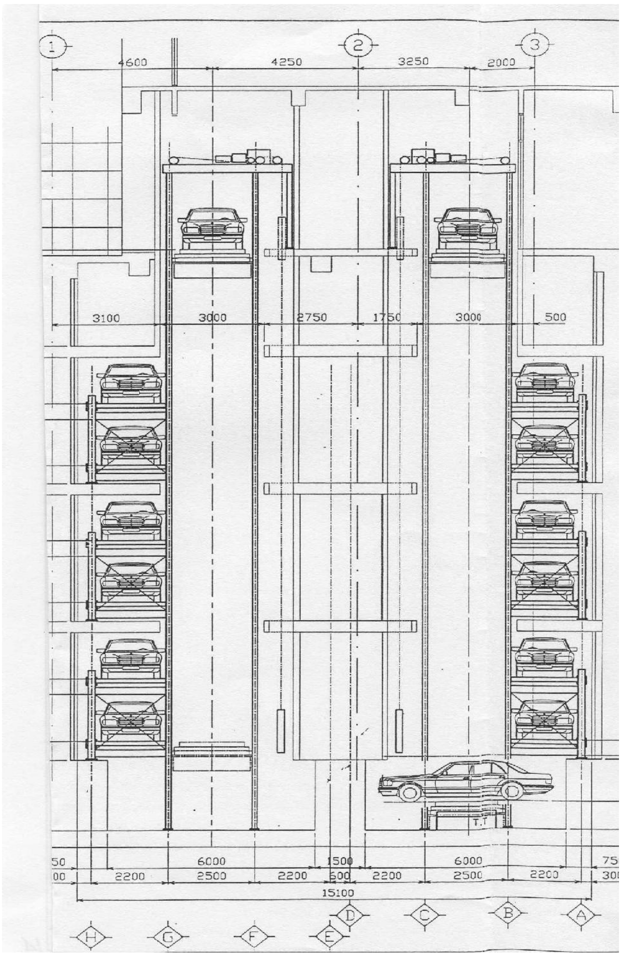


Figure 1: *Basic Movements of the Parking Process*

The components of fully-automatic parking storage system are mainly introduced as follows:

- Parking Area for Garage Entry/Exit (Figure 2)
- High-Speed Elevator (Figure 3)
- Multi-Layer, Synchronized-Operation, High-Speed Jack Plane
- Multi-Layer, Multi-Row, Parking Lot (Figure 4)
- Active Automobile-Safety Monitoring Network
- Operating Control Information Transmission Network
- Electronic Vehicle Passage Management & Subscription (Figure 5)

Wen-Ting, Liao, 2000 Jan.



Block Diagram of the Parking Storage System Structure

Figure 2 : Parking Area for Into/Out of Garage

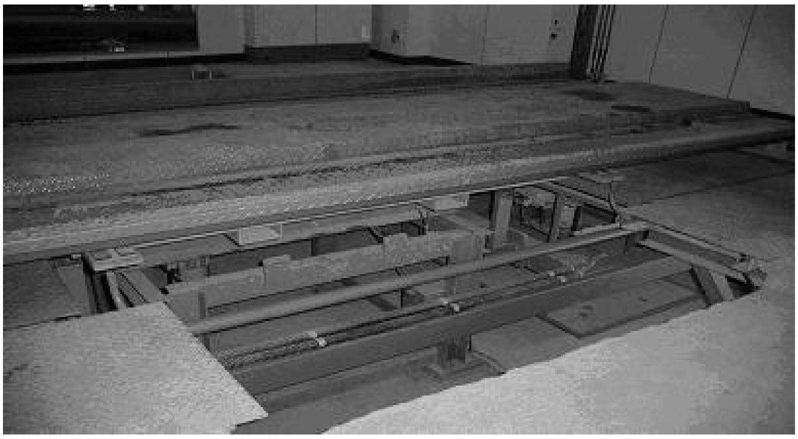


Figure 3: High-Speed Elevator

Figure 4: Multilayer Multi-Row Parking Lot

Figure 5: Electronic Vehicle Passage Control

Due to different design organizations providing a variety of design philosophies, market partitioning and technological integration methods, this study organizes those fairly common and relatively competitive parking storage systems in the market, generally introduced here:

1). Crawler-Type System: Vertically elevated, multiple groups of crawlers or universal rollers, traverse traveling driven by motor in order to conduct transport.

2). Wagon Stage Plate-Type System a): Vertically elevated, traverse steel tracks, wheeled secondary frame, operated by mainframe power (see Figure 6).

Wagon Stage Plate-Type System b): Vertically elevated, the traverse motion is initiated by the traverse's radial arm, which clamps to the groove attached under the wagon stage plate, leading it to laterally move the secondary frame (see Figure 7).

3). Comb-Type Frame System: Both vertically and laterally moved by the mainframe, the comb-type wagon stage plate makes the need for exchanging secondary frames unnecessary. Its design principle indicates that while the automobile is accessed, no empty sweep template should be reset, concerning the operation between every parking lot and a jackplane lot, whose process reduces a car's passing time (see Figure 8).

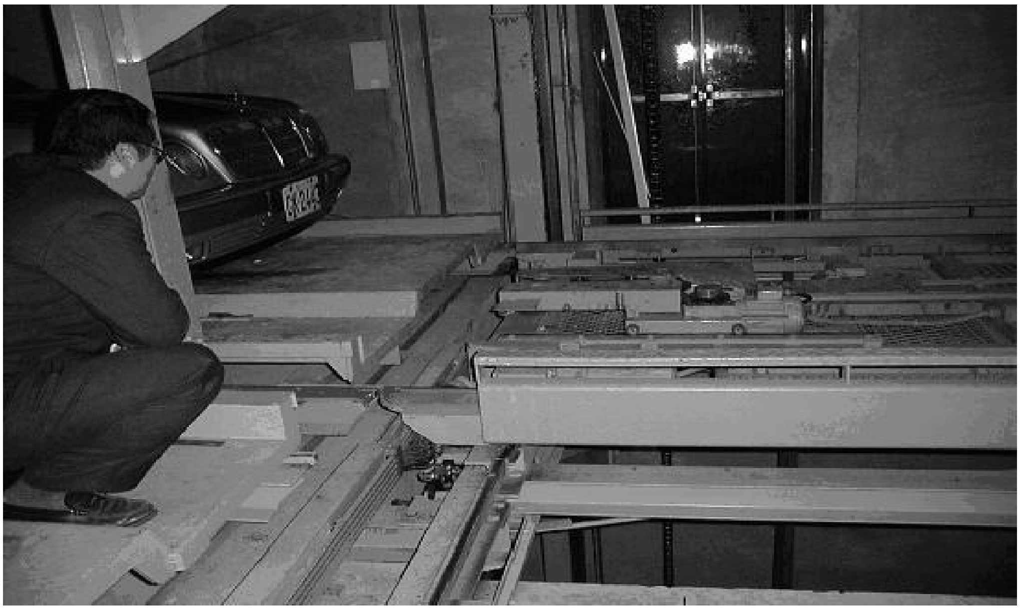


Figure 6: Wagon Stage Plate System 1


Figure 7: Wagon Stage Plate System 2

Figure 8:. Comb-Type Frame System 3

3. Analysis of Investment Appraisal

3.1 Background

In view of the increasingly deteriorating issue of car parking, accompanied with the traffic turbulence caused by illegal curb parking and the high cost of traffic jams, the government faces the situation that if those problems are not properly resolved, economic development will certainly be retarded. Besides passively restraining the decrease in the amount of cars, the policies of great importance adopted by the government are to proactively compile the budget according to the "Program of Ameliorating Parking Issues" and further accelerate the amendment and implementation of laws and regulations concerned. For example, regarding the parking storage affiliated inside architectures, available laws or regulations in Taipei cover the Essential Encouraged Aspects on Public Parking Spaces Extended Inside Architectures, which stipulates that the structures allow additional established parking spaces that should be incorporated into the floor area as calculated in the floor area ratio. The calculating process should be conducted according to the formula shown as follows (the added parking spaces do not need to be taken into consideration during the calculation process; however, the uncalculated area per building should not exceed 40 square meters.).

FA **FA** **FA**

FA Total floor area concerning the allowed essential floor area ratio as calculated.

FA Referred floor area calculated on the basis of the designated floor area ratio in the Urban

Planning Law and related laws and regulations.

FA Floor area calculated by the floor area ratio of the allowed additional established parking space, which should be less than 1/5 of the reference floor area and be incorporated into legal parking spaces as calculated.

3.2 Location Factors

The location factors that should first be taken into consideration in investing in parking areas are, including land application, compilation of city planning, average automobile occupancy ratio as concerned, existing regional number of parking spaces, time spent searching for a parking space, and the punishment possibility of broken-through parking, etc. For land that cannot be customized, the selection of investment bidding is fairly difficult to control. Thus, case analysis is demanded to be conducted for each bidding process. The average "parking supply and demand statistics" sufficiently known are used to determine the market value of the region concerned for investment.

3.3 Relation between Cost & Price

Cost factor analysis mainly includes land price, construction cost, operation cost, and maintenance cost, etc. The case of an office building in Hangchounan Road, which was launched by Fubon Land Development in the 1990s, is an example described below:

The base's total area accounts for approximately 148 plateaus, with the cost at approximately 1,500,000 Taiwan Dollars (TD). According to the planning design, the structure has been equipped with 54 parking spaces in its internal parking storage, with an individual cost of approximately 250,000 TD The case has installed 54 parking spaces on 20 plateaus. The relation between price and land cost is shown in Table 1 as follows:

It is assumed that the parking space's market quotation is acceptable for consumers, and higher than the pre-set rate of return. Therefore, the case is very profitable if the land cost is determined to be 1,500,000 Taiwan Dollars per plateau.

Table 1 :. Relation between the Cost & the Land Cost of Parking Storage Unit: 10,000 Taiwan Dollars

Program No.	Land Cost (TW)	Total Parking Space Cost (TW)	Individual Parking Space Cost (TW)	Estimated Rate of Return (%)	Price (TW)
1	3,000	1,350	80.5	25%	100.6
2	3,000	1,350	80.5	30%	104.6
3	3,000	1,350	80.5	40%	112.7

According to the case, it is obvious that the final price of the parking space depends on land cost. In other words, if the land cost is fairly high, the price of the parking space will not be correspondingly increased due to a restrained market quotation, cause of limited construction cost adjustment. Therefore, the tender investment would probably fail and eventually be terminated.

4. Condition Analysis of Architectures

4.1 Foundation Conditions

The foundation's ground shape and area are main factors in determining the appropriate type of off-road parking area. According to the Parking Area Layout Manual, it stipulates that mechanical parking lots may be installed if the foundation's width is less than 35m or the area does not exceed 1,500 square meters; cause by the limitation of the restrain of landform that self-automatic parking lots could not be established . Therefore, the optimum parking area can eventually be determined when the foundation area is between 1,500 and 4,000 square meters, by measurement accounting to adopted local conditions, evaluations, and comparisons of various parties (Ta-Yu, Lin, the Institute of Traffic and Transportation). Current data according to partitioning and estimated designs are provided at the website on capacity calculation of architectural design (www.iarchi.net), various references could then be further calculated as required by the designing process.

4.2 Roadside Traffic Factors

Under the volume specifications on architectural design and construction of the Building Technology Instructions, the automobile entranceways of such structures should not be placed on roads or locations as follows:

1) Road junctions, chamfering lines, initial points of a corner, zebra crossings, traversing of a bridge, and 5 meters within a subway entrance.

2) Roadway with a slope greater than 8:1.

3) Less than ten meters away from a bus station or railway level crossing.

4) Twenty meters within the passage ways of kindergartens, public schools, schools for the deaf, mute and/or blind, reform schools for the disabled, parks, etc.

5) Other roads or localities deemed as harmful for public transportation as determined by competent departments in the construction industry or transportation.

Open space should also be additionally prepared for an automobile's passage on the basis of calculation from one point of the automobile's passage center line, 2 meters behind a building line to the area over 60 degrees left and right of the vertical lines of the center line. The land covered should be regarded as an open space without holding the line of sight. A waiting area with a width and depth both over 6m should also be prepared due to the construction of parking areas. Otherwise, flow rate for this area's road system will fluctuate. Analysis for primary roads, secondary roads and regional roads (laneways) in the concerned area must be carried out, regarding issues such as road width, number of lanes, partitioning type, one-way or two-way lane, roadside parking control, vehicle flow rate statistics on intersection peak hours both in the morning and evening, and mean vehicle delay time, etc

4.3 Matching Requirements of Structure

1) Structural Section –The most suitable beam column construction must be calculated to match the entire system during establishment of the parking storage facility, which has a much higher requirement on the arrangement of parking lots and parking areas, the spacing layout and column positioning, the opening position of floor slabs with reinforcement, as well as the static loading on floor construction. The structural drawings should be reviewed in advance to avoid after-the-fact revision that may pose a danger to the construction's structural strength.

2) Electric & Fire Control Sections – Generator capacity, short-circuit tripping design and installation of maintenance lighting should all be taken into account, and the fire control section equipped with double-purpose equipment. This equipment should be both fully-automatic and manual, and meet the concerned fire code specifications. High-end industrial computers serve as a control center for smooth, rapid and secure operation of the parking facility under whatever operating mode, fully-automatic, semi-automatic or manual.

3) Management System –Improper operation should be prevented from occurring which could cause malfunctioning when the parking facility is in operation, and periodical maintenance is also of great importance. It is absolutely forbidden to have the equipment repaired by non-professional manufacturers. In addition, pre-service training should also be provided for operators concerning non-sophisticated trouble-shooting and emergency response. The service life of parking facilities can be prolonged while the safety of the entire structure is fully guaranteed.

4.4 Evaluation of Environmental Issues

Multipurpose projects should be advanced according to the concerned area's development. Such issues are required to be taken into consideration in combining parking storage together with buildings including: feasibility, the compatibility with it's surrounding environment, the impact on nearby traffic flow and the safety of residents in the region, the prevention of noise and air pollution, etc, should be included in the evaluation of the environmental impact for discussions in an item by item manner.

Regarding air pollution, outdoor air pollution control measures should be prepared well according to specifications in the "Air Quality Standard of Taiwan" (as shown in Table 2). Meanwhile, ventilation systems should also be mounted to ensure air quality according to the "Volume of Equipment of the Building Technical Instructions", stipulating that "In the parking area with a floor area over 500 square meters, mechanical ventilation should be provided for with the ventilation volume of over 35m3/hr per square meter for each floor."

Table 2: Air Quality Standard & Pollution Control Countermeasures in Taiwan

Standard	Aerosol Particle (um/n m)		Sulfur Oxides (ppm)	Nitrogen Oxides (ppm)	CO (ppm)
Air Quality	Limited value excluding the particle with a diameter over 10um Monthly average: 210 Yearly average: 160	Limited value including the particle with a diameter over 10um Monthly average: 260 Yearly average: 170	Hour value=0.3 Daily mean of hour values=0.1 Yearly mean of hourly values=0.05	Daily mean of hourly values=0.05 The number of days exceeding the limited value in a whole year should account for no more than 10% of the total.	Mean of 8 hours of hourly values=20ppm Daily mean of hourly values=10ppm Hourly value at whatever location/time= 40ppm
	The monthly average value should exceed the limited value for at most twice in a whole year.				
Countermeasures	To match traffic impact evaluation results, the parking area's passageway should be arranged on the road section with comparatively high traffic service quality. This is in order to avoid a high-volume discharge of pollution, which is generated by low-speed operation or traffic jams.				

Controlling the situation of countermeasures on noises vary with different noise sources Due to the semi-enclosed space of indoor parking lots, and regarding the propagation of sound, the sound wave travels parallel to the work direction of vehicles spreading outdoors, while other sounds are also reflected and transmitted between the indoor walls. The types and countermeasures of noise sources are shown in Table 3.

5. Conclusion & Prospect

Parking storage facilities are an ideal instrument in the solution to a metropolis' severely insufficient parking spaces. However, a wide range of aspects should be taken into consideration when determining the establishment of parking storage in buildings. These include: processes related to such fields as government laws, regulations and policies, the mentality and financial operation of owners, architects' planning and design and the strength calculation of structural engineers, the construction accuracy of related manufacturers and their technical exchanges with overseas counterparts, agent companies' marketing philosophy, customers' acceptance, and the response of neighboring residents, etc. After all those aspects are well arranged and integrated, the feasibility study can be finally determined in establishing parking storage and successfully combining the structure within the parking facility. Therefore, an old adage states that "good creation yet unfeasible" can be avoided.

Table 3: Noise Sources & Corresponding Preventions

Noise Sources	Causes	Methods
Vehicle Noise	**Power system and running noise generated by the friction or vibration during contact with external surroundings.**	**Vehicle noise is not completely generated by the establishment of parking space, and laws and regulations concerned stipulate that the automobile speed in lanes around the parking space should be kept under 15km/hr. Furthermore, it has also been determined that the speed of entering the parking space should be no more than 10km/h which would yield no noise level disturbance to surrounding residents. With regard to ramps, floorboards and sidewalls made of special materials should be implemented to absorb the noise generated by accelerating or decelerating vehicles.**
Mechanical Noise	**Operation of mechanical component parts.**	**Washers should be installed on the interfaces between the mechanical equipment and major structures. This process is required to conform to the "Maximum Limited Noise Level of Noise Control Standard".**
Ventilation Noise	**Start-up or operation.**	**Acoustic treatment could be utilized concerning the ventilation noise, such as a single wall, jacketed wall, sandwich wall, damping materials, etc.**

(Chen Yung-Yu, 2000 / 01)

Once the vehicles on the road have been halved, roadsides are not crowded with automobiles and all issues concerning car parking in a city are completely resolved. The road is actually the most original and creative artist in metropolitan life (Hsiehku International, webpage from www.dodohome.com.tw). The smooth, rapid, secure, timesaving and convenient parking lot is now coming into being!

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Maintenance of university premises - principles, tools and experiences in practice

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Abstract

The importance of renewal and repair older ecucational buildings is rapidly growing. Changes in use and at same the time the aging of HVAC-systems and building stocks causes need to plans repairs beforehand. The fair divide of costs is more and more important because of lack of funds. The positive side of lack of resources is that to day both the owner and the user have to think very carefully which rooms are really important. In the paper two simple pc-tools are presented. Both can be used when making long time maintenance plans and diving the costs of renovation by transparent and fair way.

Keywords: maintenance, maintenance costs, university premises, quality

1. Background and purpose of the lecture

In the real estate business the owner manages and maintains facilities for which the user, in the role of the client, defines functionality goals. In many cases the requirements set for facilities during the construction phase change. Alongside a long-term technical maintenance and repair plan, it is necessary to compile a facility development program based on the needs of the client, in other words, a functional maintenance and repair plan.

Program integration is a technically and administratively demanding process that requires customer service management, integration of a technical repair plan, efficient quality assurance during the repair process and careful documentation after implementation. To deal costs by transparent and right way betveen the owner and the user - that is in many cases the most hardest phase.

The currentness of the problem is rapidly growing. Educational, office and commercial buildings in Finland will enter their technical renovation phase in 2010 - 2020. The need to make functional changes grows as clients use facilities more efficiently. So far, no rules of the game or theories for implementing the process have been compiled.

In this presentation I'll show you some examples of simple pc-tools by which we can use to shed light on problems that arise when integrating technical and functional maintenance programs.

2. Planning of renovation

2.1 The Basis

Maintenance keeps the technical properties of a building in operating condition that corresponds to the original level. Programming of maintenance refers to a process in either the construction phase or the maintenance phase whose goal is to implement maintenance on the basis of a real estate strategy approved by both the owner and the client. A real estate strategy describes the goals which the owner and user set for the functional use of a facility. If the owner and user do not have a common real estate strategy, it is necessary when programming repairs to simultaneously examine a technical maintenance plan compiled by the owner and a functional maintenance plan compiled by the user. In such a case the plans are integrated by either speeding up or delaying technical maintenance according to the dictates of functional changes. Figure 1 presents common goals for which a real estate strategy is compiled. The importance of the goals varies, depending on the functional use of the building.

Safety in use
No disturbances in use
Support to the customer's business idea
Possibility to focus earmarked funds for planned renovation works
Possibility to measure services right and by that way find smooth stress of resources
Possibility to combine owner's and use's maintenance processes

Figure 1:. General goals for optimized maintenance and repair

The programming process consists of four phases. It includes parallel development tasks. The programming process is presented in figure 2. In phase 1 the process is assigned objectives based on the real estate strategy, and tools for cooperating are created for the owner's and user's organizations responsible for maintenance process. Repair and renewal plans are compiled in phases 2 and 3. The owner's repair plan is technical and focuses on maintenance of external structures and the building's basic technical systems. The user's renewal plan includes improvements caused by functional changes to the facility and repairs to the distribution systems of the building's technology. The limits of responsibility for maintenance are agreed on in phase 1. Phase 4 is critical from the standpoint of the success of the process. The user's customers are informed of the progress of the repairs and, for example, achievement of the goals set for the indoor climate. The measures are documented on the basis of rules of the game agreed on in phase 1.

Quality assurance covers both the technical quality of the measures and the functional quality of the process. Necessary development measures are implemented and the process is made into a routine.

In phase 4 repair costs have to be dealed between the owner and the user. Usually the owner is responsible all the planned repair costs. The functional aging cause needs for new rooms and better technical systems.

Part of these costs belongs to the user. The common way is that the the owner pays the renovation and the costs are to be included to the rent.

Co- operation process of renewal and repair work between the owner and the user (the client)
Repair and renewal plan for technical aging made by the owner
Repair and renewal plan for functional needs made by the user
Combinition of technical and functional repair and renewal plan

Figure 2. Phases of the maintenances process between the owner and the user

2.2 Implement the co-operation between user's and owner's maintenance organizations

In the 1st phase of the process the user's and owner's representatives agree on the principles to be applied in making more efficient use of the facility. These principles are:

- distribution of responsibility for maintenance between the owner and the user
- principles to be followed during implementation of repairs
- entry of changes made during repairs into the real estate information system and documentation of repairs
- planning meeting agendas and schedules

Development of cooperation is the key question of the process. The significance of this activity increases as buildings age and the need for repairs become concrete. Development of co-operation in new buildings can take place more freely.

2.3 Compiling a technical repair plan

A preliminary repair plan should be made already when the building is taken into use. The objective of a theoretical repair plan is to assess the proper level of costs during the life cycle. The assessment is based on suggested repair and renewal phases and investment costs. The assessment makes it possible to calculate a reservation for maintenance, which indicates what portion of the rent income from the facility needs to be set aside for future maintenance. Because tax legislation does not allow advance transfer of reserves for maintenance, the significance of the calculated reservation for maintenance is to indicate to the owner and user the magnitude of the costs. The theoretical assessment does not need to be very detailed, it is only used to determine the target level.

A repair plan that covers the entire life cycle or a life phase includes an estimate of costs and the timing of measures that will be implemented. The need for repair is grouped as follows:

The renovation phases can be selected in 5-year periods, for example. The economic life is usually considered to be 25 - 100 years. It is recommended to make the plan for 50 years The calculated interest rate can be freely selected (see figure 3). In planning life cycle-long maintenance, assessment of alternatives should take into consideration both the costs of the investment phase and future energy and maintenance costs.

The estimation is made by LCC. It gives us oppurtunity to see, what is the relation between investment costs and repair and renewal costs. This method is very usable in new constrcution models (so called Life Cycle Models). Anyway it must be remembered that the plan consists only repairs and renewal based on technical aging. Most cases changes in rooms are much bigger need for renovation in real life.

REPAIR PLAN 2000 - 2049			Economical life time				50			Building volume, rm^3			109734
	Educational Building 1		Internal rate of interest				4			Building area,brm^2			27000
	Rakennustyyppi						*0,0466*			Room area,htm^2			25304
RO	Kuvaus	yks	Amount yks	Investment cost [€/yks]	Repair costs KUST [€/yks]	Life cycle for renewal jakso [v]	Life cycle for repair [v]	Present value of repairs NA [€/brm^2]	Present value of renewal NA [€/brm^2]	Annual costs of repair vuosikust [€/brm^2,a]	Annual costs of renewal vuosikust [€/brm^2,a]	Annual costs of investments vuosikust [€/brm^2,a]	LCC [€/brm^2,a]
A1	Surface structures of site area	brm^2	27000	15	3	50	25	1,13	0,00	0,05	0,00	0,70	0,75
A2	Outside equipment	brm^2	27000	2	0,5	50	25	0,19	0,00	0,01	0,00	0,09	0,10
A3	French drains and piping	brm^2	27000	8,5	3	50	25	1,13	0,00	0,05	0,00	0,40	0,45
A4	Other earth and ground work	brm^2	27000	6	2	50	10	3,30	0,00	0,15	0,00	0,28	0,43
B1	Surface structures of outer walls	brm^2	27000	240	24	50	25	9,00	0,00	0,42	0,00	11,17	11,59
B2	Balconies	brm^2	27000	1	0,5	50	25	0,19	0,00	0,01	0,00	0,05	0,06
B3	Roof	brm^2	27000	9,5	5	25	10	8,24	7,06	0,38	0,33	0,44	1,15
B4	Windows	brm^2	27000	24	12	50	25	4,50	0,00	0,21	0,00	1,12	1,33
B5	Outer doors	brm^2	27000	6	3	50	25	4,95	0,00	0,23	0,00	0,28	0,51
C1	Internal doors	brm^2	27000	12	3	25	10	4,95	8,92	0,23	0,42	0,56	1,20
C2	Surfaces of rooms	brm^2	27000	76	25	25	10	41,21	56,48	1,92	2,63	3,54	8,09
C3	Fittings, equipments and installations	brm^2	27000	50	17	25	10	6,38	37,16	0,30	1,73	2,33	4,35
D1	Heating system	brm^2	27000	17	8,5	50	25	3,19	0,00	0,15	0,00	0,79	0,94
D2	Plumping and sewage system	brm^2	27000	28	14	50	25	5,25	0,00	0,24	0,00	1,30	1,55
D3	Ventilation system	brm^2	27000	58	29	50	25	10,88	0,00	0,51	0,00	2,70	3,21
D4	Electicity system	brm^2	27000	80	40	50	25	15,00	0,00	0,70	0,00	3,72	4,42
D5	Lifts	brm^2	27000	30	15	50	25	5,63	0,00	0,26	0,00	1,40	1,66
D6	Other HVAC-works	brm^2	27000	2	1	50	25	0,00	0,00	0,00	0,00	0,09	0,09
										(b)			
	Yhteensä, euroa									5,82	5,10	30,96	41,88

Figure 3: The magnitude of repair costs is determined with the help of a maintenance plan compiled in the investment phase. It is recommended that the repair plan is based on life cycle costs, not only investment costs.

The accumulation of repair costs during use is usually not linear. The need for maintenance in the initial phase is minor and the need increases as the building ages. Nevertheless, in order to plan maintenance, an estimate of maintenance costs is needed. An educational building is used as an example, where the economic life is considered to be 50 years and the calculated interest rate is 3 %. Figure 4 present accumulated maintenance costs during the life cycle.

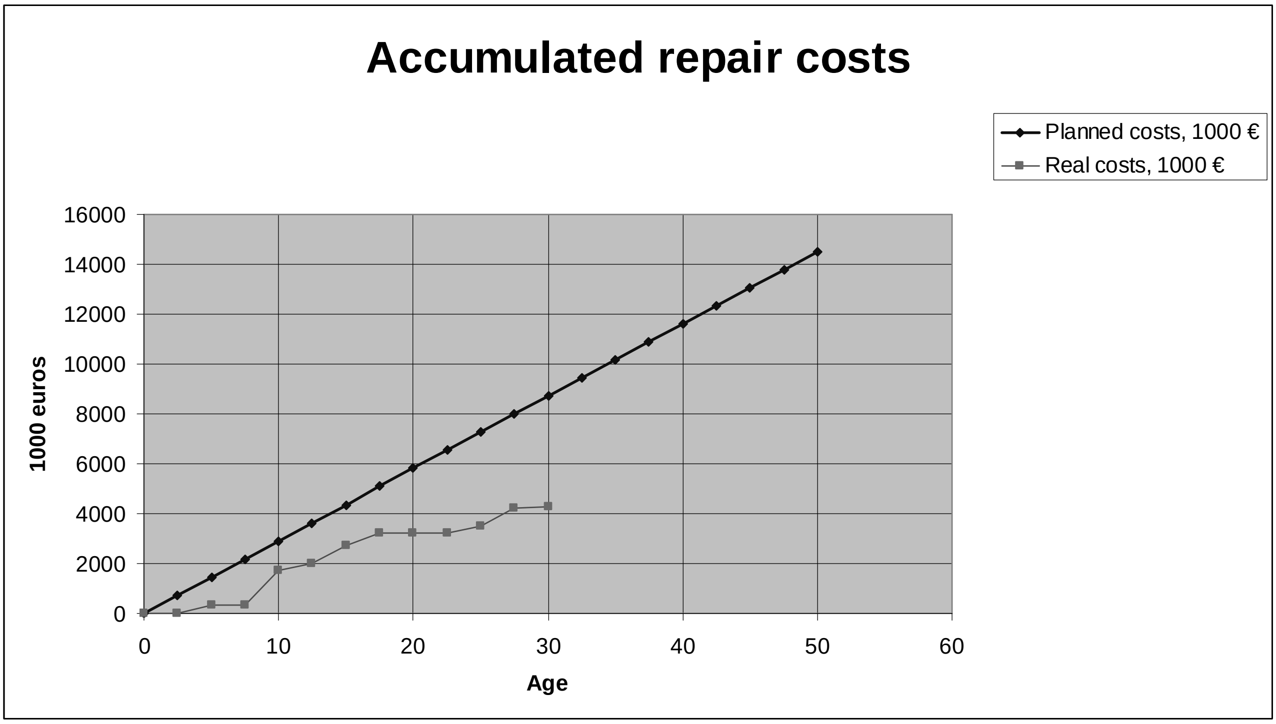


Figure 4: Timing of maintenance costs during the life cycle when accumulated maintenance costs are assumed to be linear. The white arrow indicates the difference between actual and theoretical repair costs during the life cycle.

In practice, it is not possible or even expedient to adhere completely to the theoretical repair model. There is considerable variation between the maintenance phases of different buildings, and other repairs resulting from changing needs in functionality are also always done in conjunction with maintenance.

In actuality, the need for repairs is based on periodic condition assessments and supplementary condition studies. A general operating model for condition assessments has been developed in Finland for both residential buildings and commercial and service buildings. Guidelines also exist for the most important condition studies.

A repair plan is always separately compiled for building components for which the owner is responsible (structures, building's technical systems) and for facilities where responsibility for maintenance can be divided between the owner and the user.

2.4 Compiling a functional repair plan

The owner's task in the maintenance process is to maintain such features of the building which ensure that the user's activities are safe, healthy and as profitable as possible. The user's needs change over time. Changes in functions may require

- new construction to provide additional facilities
- changing the facilities to better serve activities (dividing or combining rooms)
- improving the properties of facilities by technical means (structural improvements or technical improvements)

	KÄYTTÄJÄN TOIMINNALLINEN PTS																							
	Tiedossa olevat tilamuutostarpeet ja peruskorjaukset, tekniikan muutokset lisättynä																	S=suunnittelu						
																		R=rakentaminen						
	PERUSKORJAUSTEN AIKATAULU RAKENNUKSITTAIN BUDJETTIVUOSILLE 2003-2008																							
1.	Rakennus 1																							
Aikataulu	VUOSI		2003	Määrä	Kust.	2004												Määrä	Kust.	2005				
Nrot	Kuukausi			[m2]	[€]	1	2	3	4	5	6	7	8	9	10	11	12	[m2]	[€]	1	2	3	4	5
1.	Tilan nimi																							
1.1	Hanke 1			500	300	1.1																		
1.2	Hanke 2			600	250	1.2																		
1.3	Hanke 3			300	200	S		13	1.3															
1.4	Hanke 4			600	260	S			1.4															
1.5	Hanke 5			600	800			S		1.5														
1.6	Hanke 6			600	200						S				1.6	R		600	150	RR				
			Yht.	2900	1310													300	-150					
2.	Rakennus 2																							
	VUOSI		2003	Määrä	Kust.	2004												Määrä	Kust.	2005				
	Kuukausi			[m2]	[€]	1	2	3	4	5	6	7	8	9	10	11	12	[m2]	[€]	1	2	3	4	5
2.	Tilan nimi																							
2.1	Hanke 7			240	100						S		2.1	R										
2.2	Hanke 8			100	0											S	2.2	100	25		R			
2.3	Hanke 9			125	40				2.3	R														
2.4	Hanke 10			230	0													230	80	S		2.4	R	
2.5	Hanke 11			200	0																			

Figure 5: The user compiles a general schedule for functional improvement projects, which is integrated with the owner's technical maintenance plan.

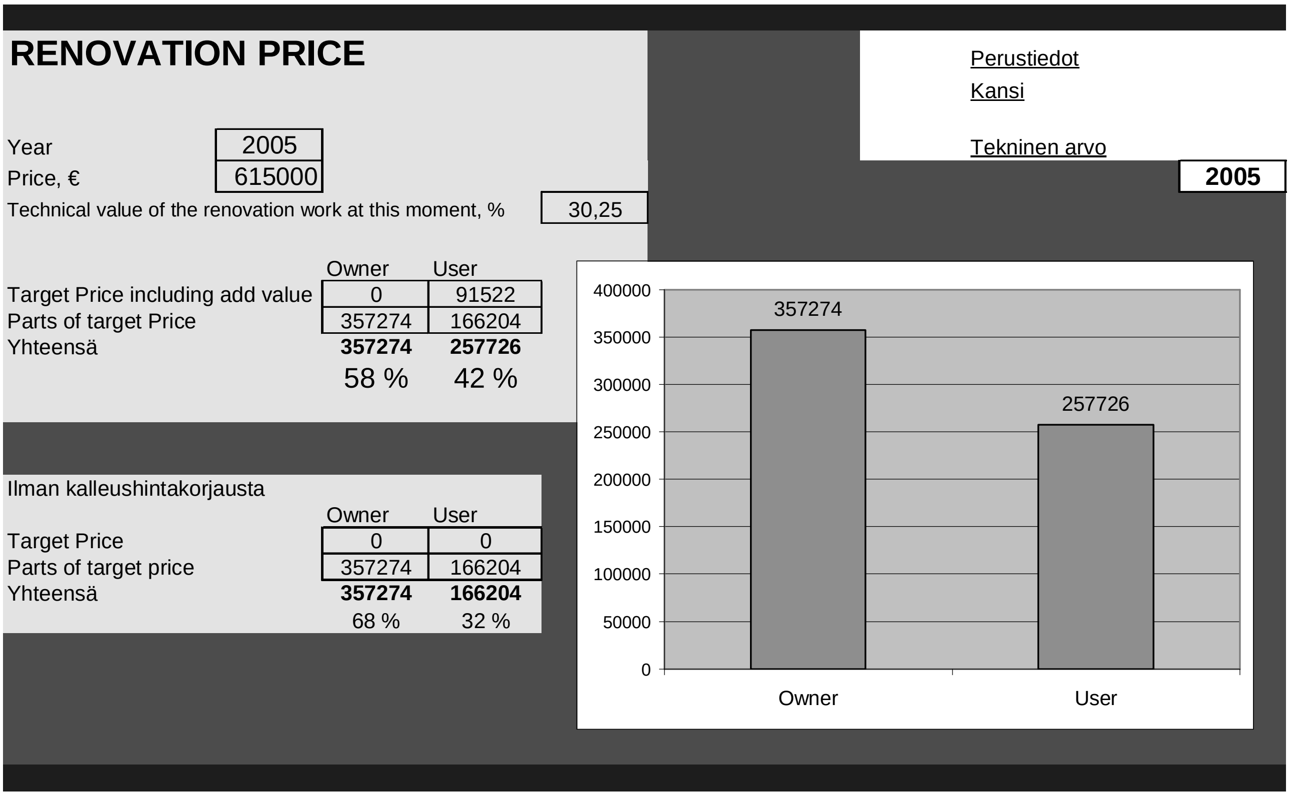
Small user organizations usually do not have resources for programming functional changes. The problem with large users is the considerable number of customers, in which case programming needs to combine many different wishes.

Figure 5 presents a good example of a maintenance plan compiled by a user, where projects are timed over the planned period. The length of the planned period is usually 5 years.

2.5 Integration of the technical and functional plans

In order to be able to integrate technical maintenance, which is the responsibility of the owner, and functional improvements, which are the responsibility of the user, the user's maintenance plan needs to be joined to the technical maintenance plan. Part of the cost effects belong to the maintenance responsibility of the owner, and part are the responsibility of the user. In practice, the owner usually has the repairs done, and changes which are clearly caused by functional needs have an effect on the rent of the facility.

In integrating it is important to determine how the responsibility for repairs is to be divided between the user and the owner. The distribution can rarely be made only on the basis of the technical age of the building components, since it is possible that varied amounts of repairs have been made to the building components during their usable life. Furthermore, functional changes are made in the facility which result in changes to its properties. Figure 6 presents a model for dividing costs.



Year	2005	
Price, €	615000	
Technical value of the renovation work at this moment, %	30,25	

	Owner	User
Target Price including add value	0	91522
Parts of target Price	357274	166204
Yhteensä	**357274**	**257726**
	58 %	42 %

Ilman kalleushintakorjausta

	Owner	User
Target Price	0	0
Parts of target price	357274	166204
Yhteensä	**357274**	**166204**
	68 %	32 %

Figure 6: Cost distribution model for dividing the cost of facility repairs, where the change in technical value is based on progressive depreciation.

3. Conclusions

Organizations that are responsible for users' and owners' real estate management in Finland are generally professionally very competent. There is an abundance of technical tools for facility management. It has usually been possible to agree on the main principles used to reflect the costs of maintenance and modifications in facility rent.

The need for functional development of facilities in university buildings, in particular, will be very significant in Finland in the near future. Universities in Finland mostly operate in facilities owned by Senaatti-kiinteistöt. Senaatti-kiinteistöt is a professional real estate owner whose main objective is to function as a service organization and as far as universities are concerned, to be a responsible partner that develops its facilities. The development of the products presented in this presentation has been commissioned by Senaatti-kiinteistöt.

Enhancing partnership is a continuous process. At the strategic level, partnership can be developed, for example, as follows:

1. Compile a vision of operation in 2015, for example, together with the user

2. Compile an estimate of the facilities needed to implement the vision

3. Compile economic planning calculations of the effects of the costs of the target state on the user's operating costs and prioritize the vision's focal areas of development

4 Compile a plan of how technical repairs can be made to support implementation of the vision in the best way possible

5. Develop the owner's customer relations management, create real benefits based on a regular customer relationship.

At last - buildings are only resources. The money we need for maintenance and operations is also a resource. We have to remind that universities are places where the seeds of better global future are seeded. That is why it is highly recommended that co-operation process between owner and client consists of any high barriers. My own experiences after having involved as a small part of the process tor three years are, that people in both sides are so educated that provisions for managed co-operarion really exist.

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Relating Housing Maintenance and Professionalism of Owners

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Abstract

Reports about poor condition of dwelling stock discuss about lack of proper maintenance and about poor repair of the dwellings in shared ownership. These reports do not always touch the role of the (co-)owners in the whole process, rather the papers are concentrating on the affordability issues – the vast majority of the households still cannot meet their housing costs.

Current paper is based on the results of research done for the Nordic Council of Ministers funded project 'Developing professionalism for housing maintenance management in the Baltic States'. Housing maintenance related professional associations of the three Baltic States have been the major partners to this project.

The following issues are to be discussed in the paper:

- role of condominiums (home-owners associations) and the relevant non-governmental institutions when improving the housing environment
- professional services and raising public awareness about housing maintenance
- lack of reliable data about housing conditions

Contemporary facilities management (incl. housing management and maintenance) requires wider introducing of the principles of informed owner in the property market, requiring significant degree of operational knowledge and experience. Housing maintenance has become a customer-oriented service industry where the service providers are organised and running their schemes for professional certification. Especially in the transition economies the key-counterparts – the owners of the dwelling units – are often lacking any informational support and possibilities to co-ordinate their activities.

Keywords: facilities management, maintenance; housing stock; owner-occupation; intelligent owner

1. Role of maintenance when preserving property

Until very recently, designers of buildings and advisors for the property owners have focused their main attention on capital costs, paying little heed to the interest to forecast maintenance and other running costs. Yet over the life span of a building, expenditures for maintenance and proper repair may be at least 2 or more times of the initial costs. [1] Moreover, though manufacturers advertise about availability of maintenance-free materials, the costs for maintenance are growing on most of the buildings.

'Maintenance' as term has been missing from the professional terminology not only in the East and Central European (ECE) countries, but this term has not always been very clearly defined in the western countries. [2] Rather often maintenance is used in direct connection with repair and refurbishment activities; accordingly these activities and the related to these costs are sometimes handled as one causing major confusion in the field. [3]

Any structural part of a building or a utility-system requires relevant maintenance to be planned and carried out there to assure they provide the necessary service for the users and the environment remains safe and sound. Correspondingly, not only the originally installed and currently ageing structures of buildings (built either during the soviet period or even much earlier), but even the newly built, or refurbished, or restructured, or reinstalled finishing and structures, though especially the engineering service systems would require planned care taking. Even the very different construction projects developed today rather often do not foresee any activities for regular maintenance during the period of use.

Buildings – their structures and the engineering services – that are not maintained as required will cease to fulfil their intended functions. Regular maintenance that has been carried out just-in-time for preventing and doing away with the defects while they are still minor is generally considered as the most cost-effective strategy for providing well functioning buildings. Planned maintenance can normally prolong the useful life-time of the structures and systems almost indefinitely as replacement will be required less often; accordingly operating costs will be reduced for the owners and users, but also less resources will be used and wasted for the society in general. Moderate financial inputs into maintenance enable operators to extend the life-span of an existing building until a replacement will be required.

Buildings are developed to satisfy different human needs – we may talk about buildings that are developed for different business but also living purposes. 'Facilities management is the provision of the physical infrastructure necessary to best support the achievement of an organisation's primary objectives. It is a managerial service related to the continuous provision of space for working and living.' [4] This is one of the oldest and the most traditional definition for facilities management (FM) provided in academic literature. Thus, all the activities related to servicing the buildings and the users located there may be covered by the umbrella term FM. And it is of major importance to understand that these are not only the walls and structures (created by the construction professionals) that are required by the different users of the buildings – the users require quality-services to be provided during the period of use.

In fact, any company, and a public office, and a household are organisations requiring adequate space for their major activities – either for business, or for public administration, or for living. This-why for a FM professional there should be no major difference what is the purpose of the organisation he is servicing – facilities manager has to understand the specific interest of the end-user-organisation and based on this information as input to build up a network of in-home or outsourced service-contracts from different most adequate providers. Maintenance services are amongst these services that are to be provided for the buildings anyhow to satisfy the requirements of the users.

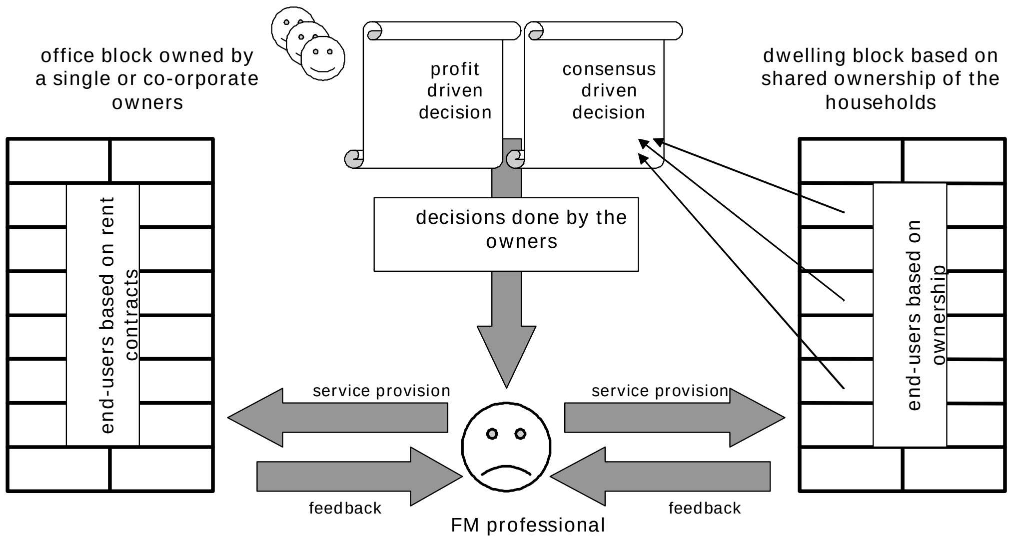
Maintenance services provided by a relevant contractor do not automatically create a good environment for the users – maintenance helps only to develop required conditions for suitable and adequate using of the premises. Though, poorly provided maintenance always leads the users of the premises to question the facilities manager about the reasons for not adequate quality of services delivered for them. Poor quality of maintenance is usually a result of lack of consciousness and knowledge among one or more of the parties acting in the FM market.

2. Relating housing sector and facilities management

Dwellings are valuable assets which are normally built up using substantial investments over a long period of time, but these assets are not always managed and maintained with the care that they actually deserve. The experience of the author of the paper gives the evidence that in many countries in East Europe building maintenance is insufficient or in fact non-existent. [5,6] The resulting deterioration reduces the ability of dwellings to perform the intended functions designed for these buildings. For example, a heating system requires similar maintenance technology to be implemented either in a block of offices or in a block of flats – only the output performance level may differ as to timing of the inside temperature requirements may differ.

Though for the maintenance service providers there is no technological difference when arranging and providing services for the user organisations in different buildings, there is still considerable difference for the facilities manager especially when business and housing premises are concerned. (Figure)

A block of offices is owned either by a single owner or by a corporate owner; most of the small business organisations are relatively short-term tenants in these office-blocks using one or a couple of office units there. The owners of these blocks are interested in having tenants using the premises and facilities. Tailored for the user's needs and in adequate repair premises are prepared for them; afterwards regular and reliable cleaning service – but not only – plays an important role to assure satisfaction of the tenants as the clients. Quite often in 2-3 years most of the user-organisations restructure their company-structure, sometimes this restructuring may be rather considerable. The facilities manager has to refurbish and rebuild the premises, though technically these premises may be excellent and they may still meet the common aesthetic requirements. The user organisation may even move out of these excellently maintained premises in any moment not dependant on the quality of services provided for him; removing elsewhere may be related to better functionality or better location of the new premises that will fully meet the current needs of the organisation. In any case the facilities manager in charge for the premises has to start looking for the next tenant organising total refurbishing even if there have been no any crucial damages



caused to the vacant premises.

Figure: Role of FM professional when managing different properties

In a block of flats in the case of condominium type shared ownership organisational behaviour is different. Considering the experience of the Baltic countries due to massive privatisation of flats in large-scale housing in average there are about 50 up to 100 co-owners in a block there. In this case though the ownership-rights for the block are shared, each household has still the right to say a word and participate in deciding about the repair-level of the block. In the case where the owner-occupation ratio absolutely prevails – in Estonia and Lithuania the total ratios of owner-occupation is more than 95 per cents – getting consensus is extremely difficult; when making decisions each household will rank their household-interests as the priority ones. As currently there is still not much variety and possibilities for the households to move into different blocks being more adequate and affordable for them, accordingly the structure of the residents in the blocks remains stable and each of these co-owners will give the highest priority to private and household's interests.

The major difference when maintaining these two blocks is based on the motivation of the decision-makers. In the office-block the owners are profit-led when making decisions and quite often they use the facilities manager as the adviser to get financially the most feasible solution. On the contrary, most of the flat-owners have limited budgets for their households though they are also looking for ‘best value for money’ they are aiming to the same target through cost-reduction. On the general meetings of the owners rather often there appears the clear conflict in the interests of the owners and the facilities manager – the latter is obliged to carry out professional service which is inevitable related to certain costs, on the other side his activity is limited with costs which rather often are not adequate for the target.

Facilities manager is the mediator, not the decision maker, who has to turn the owners’ decisions into practice through providing relevant maintenance services. In different blocks decisions may be differently targeted, though the technical specification of the service is quite the same; in any case the facilities manager cannot initiate providing any services that are against the will of the owners.

Rather often it is stated in the papers and reports that massive home-ownership in large-scale housing stock is not affordable! [7] As the quality of these blocks from 60es – 80es is poor and no refurbishing has been done there for about two generations, correspondingly to make these blocks habitable to meet the current technical requirements will require too much sources by the households to be invested. Though most of this housing stock in the ECE countries is currently privately owned and the flat owners (or homeowners) are responsible for all the costs related to these blocks, still there remains rather heavy burden on the society as well. Too many of these households – though being the owners of the properties – still require different housing allowances and the neighbourhood renewal projects require also considerable investments to be done by the authorities.

The numerous surveys give clear evidence that the households and the homeowners’ associations (HOA) quite often reduce their housing costs through avoiding preventive maintenance. Only emergency maintenance is considered to be inevitable, but in long-run this is always relatively more expensive as ordering the works for preventive and routine maintenance.

The attitude to solve the affordability related problems through avoiding maintenance gives only short-term ‘profit’ or ‘benefit’ for the home-owners – affordability level of the sitting households is improving, the next generation has to pay the ‘not-paid’ bills. Doing away with regular maintenance reduces the level of sustainable living-conditions both for the households located in the block, but also for the society in general. Dwellings that lack normal maintenance will burden the next generations with much higher costs related to housing stock; if by this time it will be still feasible to make any investments to improve these facilities. In any case the initial target to create the housing stock of adequate quality will remain unreachable; avoiding maintenance will reduce the general level of sustainability in the society and in housing sector. This is the decision-maker’s ‘trap’ in there.

Decision makers in housing often do not pay much attention to management aspects of the building. This may be because they are not fully aware of the financial implications caused by poor care to the buildings they have been appointed to manage. This is still a rather typical approach to the problems in the housing sector – there is an institutional ‘somebody’ who is the decision-maker and everything depends on his awareness and competence. Poor maintenance usually results from lack of awareness amongst these decision makers and the residents of the buildings; therefore the buildings are not managed professionally and maintenance in particular is not given high enough priority – resulting in unnecessarily high operating costs and low building standards. Improvements in the management of such large building stocks can save reasonable amounts of money.

High prices for houses and fees for housing services, also for maintenance works, are much discussed in media; also the problem of continuous disrepair is understood by most of the households. As the property owners they are legally responsible for funding all the works to keep up their properties meeting certain standards; but money required for maintenance works comes directly from the budget of the households accommodated in the block, households are interested in influencing the decisions done in the way that the expenditures from the budget of their household would be minimal – low costs are ultimate priority! In fact, this is fully clear and understandable from the human point of view. This why, all the scheduled activities of preventive nature – if not inevitably required when the decision has to be done – are post pond. Shortage of funds by the owner-occupier households is the reason for poor maintenance, but also lack of awareness about the consequences when scheduled preventive works are not executed.

The basic human need for shelter is defined as the housing problem in terms of quantity and quality: is there enough housing to go round, and is it of satisfactory standard? But often the physically decent or even excellent standard cannot guarantee satisfaction for the tenants when the facilities in question are poorly managed, or the expenditures for keeping these up are not affordable for the person responsible for cost-covering.

Successful management of dwellings is almost completely based on skills and efficiency of facilities management services provided, therefore requiring skills and knowledge not only about the financial and technical-engineering aspects, but also social-managerial aspects are of crucial importance.

3. Intelligent owner – key-actor in the market

Professional and quality FM services are always connected with relevant expenditures; any property owner will require these services to be provided. Therefore, based on the basic principles of FM [8] only the largest property-owning organisations can benefit from the strategic approach to FM. The whole housing sector – though it consists of a large number of estates of reasonable size – during the privatisation has been split into rather small and independent management units (home-owners' associations – HOA-s). Professionally reasonable FM advice can be provided for the whole estate, but these recommendations may be of no great value for particular block and for a HOA as they may be in lack of relevant finance; but even if the money would be there, not always there is common understanding in this block about using these sums.

During transitional changes the general trend in the housing sector has been from a parochial and highly regulated and centrally managed market to one, which is increasingly deregulated and split into small and rather unprofessional units where conflicts and different viewpoints and interests govern. Even if professional FM-consultancy is provided for the HOA to improve the current condition in the blocks, the final decision lays anyhow after the owners who will vote democratically keeping in mind private priorities. The majority of owners are not professionally skilled as for construction, maintenance and facilities management services.

The role of an informed owner in the property [9] but also in the housing market requires a significant degree of operational knowledge and experience to:

- understand and clearly specify the service requirements and targets that are most suitable for the property they own;
- arrange the relations amongst the co-owners when managing property;
- understand and develop service delivery strategies and to manage the implementation of outsourcing strategically most important services;
- agree when monitoring the standards used when describing quality levels of services and benchmarking performance;
- manage different contractors for cleaning, maintenance and repair works and monitor their performance level;
- understand relevant financial, technical and managerial reports provided for them;
- be ready for negotiations with contractors or users of the spaces and for decision-making agreeing changes to service requirements;
- develop his/her own owner's skills through awareness raising, but especially through regular training.

Based on the criteria listed above, educating the property owners (especially owners in the housing sector), it is vital for managers and operators to enable them to fulfil their roles and perform their full professional potential in the market.

Administering of owners obligations may be viewed as a three-fold list of activities to be covered. An owner has to consider any activity listed how it can be carried out in practice to meet his or her interests in the best possible way:

long-term decisions

- introducing a maintenance manual for the property – the building and its structures – and assuring reasonable performance of it
- compiling a relevant economic plan (business-plan) to run the property following the requirements described in the manual
- planning schedules for maintenance works for the forthcoming years

- preparing and signing long-term contracts for preserving the property and getting necessary utilities services
- assuring the availability of professional supervision to guarantee that all owners interests are reasonably followed
- deciding about developing different projects to refurbish and renovate the building to improve its quality and meet the changing needs of households

operative decisions to

- assure that routine and regular monitoring of the situation and condition-assessment is be carried out on the property
- supervise over different contractors/workers performing scheduled maintenance works
- plan and order all necessary security measures, incl. negotiating reasonable insurance
- assure that professional teams are available to treat emergency situations
- take decisions about organising tenders; incl. setting up a list of criteria for selecting the best bid
- prepare and sign contracts for maintenance with suitable contractors

administrative decisions

- taking reasonable decisions about employing staff and assuring that the owner can properly fulfil an employer's role
- forwarding relevant authority to any person who can represent owners in negotiations or dispute settlements
- related to administering financial and technical documentation about the property
- assuring the availability of all necessary reports and taking decisions based on analytical data about the results of maintenance

4. Some conclusions and findings

Contemporary property management (incl. housing management and maintenance) requires introducing the principles of the informed owner in the property market, requiring significant degree of operational knowledge and experience. Housing maintenance is a customer-oriented service industry. The service providers are organised to professional associations and running their professional competence and certification schemes. The key-counterparts – the owners – are quite often lacking any informational support and co-ordination in their activities.

The following questions are still to be highlighted for further studies and debates:

- who should have the major incentives in the society and/or in the business sector for organising and training the residential property-owners in the society?
- what is the role of the state and/or the municipalities when organising these awareness raising schemes who have been the institutions standing behind the massive privatisation?
- what is the public attitude and the general understanding of ethical behaviour in the market – is it considered fair behaviour when the service providers themselves start training the owners as their potential clients?

The result of the study done within the project however has been targeted is to rise as many questions as possible, though currently it was even impossible to supply the data that was requested. One finding that came through very strongly is that many individuals and institutions involved in the study have not robust performance about management and maintenance systems in place.

Difficulties have been experienced concerning the use and meaning of terminology. It cannot be the aim to come up quickly with fully harmonised maintenance related terminology. Currently maintenance is rather widely used not only by the professionals, but mostly by the politicians and in the legislative documents as an umbrella-term and though several publications and presentations done during the last couple of years it will require much time to become accepted in the society.

Most of the estates visited during the project are in poor physical state due to the neglect of essential repairs and maintenance for many years. In many large-scale housing estates especially the residents have become dissatisfied with the management of their estates; the residents – mainly the owner-occupiers of the privatised flats on these estates – complain of lack of commitment by the authority staff which is said to result in repairs and cleaning not being performed and in general neglect of the estate and its surroundings. Thus, the authorities have treated the privatised housing as property owned by them – the actual owners are fully distanced from the possibility to make decisions.

Collaborative activities are needed amongst leading practitioners, education and research sectors to ensure that the processes in housing maintenance are fully understood by the decision-makers, knowledge and experience are shared by the counterparts and that professional and ethical standards are established to provide the benchmarks for resident interests based effective practice.

Engineers and other technical staff employed for managing maintenance of housing estates are too often by training background mainly oriented towards new construction; maintenance is always perceived as direct extension of the original construction process that should and could be carried out by professional building staff. Therefore several housing maintenance organisations are often subsidiaries for construction companies with good technical competence and equipment, but far away from the estates and targeted to doing works on the sites rather than providing residents targeted services. Maintenance has to deal with the existing buildings and with the needs of the households living there; accordingly many routine maintenance activities absolutely do not require technical skills rather human understanding. Therefore, in addition to educating the owners also professionally skilled maintenance managers are required.

5. Acknowledgements

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A New Paradigm for Construction Demand and Delivery: Developing a "Living Building" Concept

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Abstract

Managing construction projects and life cycles of built objects including their dynamics, and the inevitable changing circumstances and environmental context has proven to be difficult. However, procurement and supply strategies in construction are often based on a static approach: fixing briefs and contracts at the beginning of construction projects, when many issues are obviously still unknown or unresolved, many parties are not yet involved in the process, and change orders through the project and the life cycle are not yet known. This paradox calls for a shift from static to dynamic control of projects and life cycles, towards a "living building" paradigm of construction. This means introduction of new models, methods and contracts enabling to cope with the dynamics of construction projects and life cycles, and assuring that value is delivered and maintained adequately under changing circumstances.

In this paper a concept is presented to develop a "living building" paradigm for construction. The concept addresses two basic problems that currently exist in design and construction processes, leading to many conflicts between demand and supply. The inefficiency and ineffectiveness between demand and supply is caused perception of demands and solutions, combined with process statics and fragmentation in time. The development of the concept is based on a dynamic and interrelated approach to the demand and the delivery of built services. The concept implies new principles for procurement and supply strategies, process management and alliances between stakeholders involved in construction projects. The next step in the development of the concept is the extension of the new paradigm through the entire life cycle. This includes the formation of stakeholder alliances for the life cycle aimed at the maintenance of the long-term functionality and serviceability of built objects. Ultimately, this must lead to a shift of the construction industry as a whole from a project delivery industry towards a built service sector.

Keywords: construction projects, life cycle value, dynamic control, price development, process statics.

1. Introduction

In construction, demand and supply of value can be a complex undertaking, particularly for large construction projects involving many parties and long lead-times. The main problem identified is the intrinsically dynamic character of the process, and the changing and often diverging perceptions of parties of the outcome of the process, versus the static approach to the control of the process, because of formal arrangements between parties. What is needed for the effective control of construction is an aggregate and comprehensive model to be able to dynamically and effectively control and adapt demand (clients' value) and supply (delivery) in an integrated manner through the entire process, and idealistically through the whole life cycle of built facilities. Such a "big picture" model or "master plan" method has not been common in construction, but is essential to be able to control the complexity of building.

The concept presented in this paper represents an abstract, "sociological", or even "philosophical" view on building and built services. The concept is called the "living building" concept to indicate the dynamic approach to built services, the construction project, and the life cycle. In the concept presented the basic economic parameters value, price and costs are defined and interlinked on a high abstraction level representing the performance of the built service. The basic premise is the dynamic character of the connection between value and costs, price and performance, and therefore should be controlled dynamically; so no prescription of output against a fixed price, but rather defining a dynamic connection between performance and price. The concept is representing a further development of the concept of dynamic control, which has been introduced by the authors in previous papers [1] [2] [3]. The concept is based on the essential notion that the world is changing. Second construction is a social activity: Construction implies complex product development in a changing context, involving many parties, delivering products with value to society, pulling high levels of resources from the economy. Construction projects often take long time, and the life cycles of built services are long. During the construction process, the level of information and knowledge grow, by both the client and the supplier. Demand and supply influence one another. So requirements of buildings change constantly. Demand must be adaptable and supply must grow along. Procurement and supply strategies as well as project and life cycle management arrangements must be able to cope with these dynamic mechanisms. This calls for a reconceptualisation of the demand, delivery and life cycle management of built services.

2. The "living building" concept in construction

2.1 The problem of perception

The basic reason and rationale of a "living building" concept in construction is based on two underlying problems in construction: perception and process statics. These problems start with the demand and the fact that the first demand is basically always incorrect or incomplete, while it is impossible to demand before knowing what is available and possible, nor is supplying without knowing on a basic level what is wanted. So demand and supply are intrinsically connected, and this should be reflected in the process towards delivery of built services. However in current construction practice, this is often not the case. Demand and supply are relatively disconnected. Consequences are extra work and creation of extra value after establishing what had to be delivered after all, or work or value delivered in vain when finding out what not had to be delivered. This is basically the result of the tension between value and costs, i.e. the interest of clients' value versus suppliers' profits.

2.2 Construction process statics

The ideas and expectations of a successful project are often subjective, implicit and contradictory. For whatever reason there is always a need for change during process, so there is a need for a dynamic approach. This is particularly true in construction, where there are often no formal rules, no strict hierarchy, no fixed product, variable projects, many parties involved, unsynchronised involvement, absence of one party who has complete overview and authority. Traditionally, the "natural response" in construction is to try and fix and isolate various aspects as much as possible, including fixing the price and the design early in the process, which leads to quasi-certainty, process statics and disproportional additional transaction costs. Due to the fragmented and delegated control, and long demand and supply chains, changes come often too late to be able to effectively and systematically deal with. Change orders take lots of effort to follow up, and are often compensated through extensive rework or claims [4] [5].

2.3 Need for a dynamic approach to construction

The problems of perception and process statics and the paradox between static control and dynamics of construction life cycles call for a dynamic interrelated and long term approach to the demand and supply of built facilities aimed at systematic and adaptive maximisation of the total life cycle benefit (total value minus total costs) of built services. Value and costs are time dependent, thus the dynamic process must be aimed at the continued maximum benefit. When the total value could be interconnected qualitatively and quantitatively to the total costs of a built service, and parties would agree on the algorithm between value and costs, then the collective of demanding and supplying parties can aim the process at achieving the highest possible benefit to the mutual advantage of both demanding and supplying parties.

The contract will then not prescribe an absolute performance output against a fixed price but rather define an agreed-upon performance-price balance, i.e. value-costs balance. Within a "performance related partnering" arrangement the process can then be dynamically controlled, i.e. clients can alter their initial demand and calculate the impact on the initial price, and vice versa supplying parties are enabled to come up with new solutions that may reduce costs, or deliver additional performance output increasing client value. The initial price will grow within this dynamic process in a controlled way to a final price that may be higher or lower than the initial price for the initially planned performance. Instead of enforcing the initial planned performance against a fixed price calculated in the first phase of the process, the price is based on the actually delivered performance at the end of the process. The final price goes up to the maximum of the initially set maximum guaranteed price, not exceeding the planned budget of the client. The range between initial price and maximum budget can be considered as the client’s “control budget” for dealing with problems of perception and additional value delivered through the process. Because of the transparency of the process, on the supply side, contractors and other parties are enabled to reserve budget too for extra investments to reduce costs or increase value. This approach can be defined for the project scope only, but can be extended to the whole life and the facility management of built facilities, and be implemented to a variety of contract formats from build-only contracts to more inclusive “DBFMOT” kinds of contracts.

3. Principles of the “living building” concept

3.1 Procurement strategy principles

The client’s budget needs to include a buffer for dynamic control by the client. The supplier (e.g. contractor) sets an initial price for a basic solution to meet the client’s initial wishes. The buffer between the budget and the price is used for unforeseen changes and change orders; changing demands, requirements, regulations, standards, technology, finance etc. The following procurement process is based on a continued process of “price development”: it starts with an initial price for initial design, through a final price for actually measured additional output at the moment of delivery, and next constant measurement of delivery of life cycle value (figure 1). This process can be capped, e.g. by means of a guaranteed maximum price [6]. Thus the lowest price is must not necessarily be the client’s main selection criterion and driver. Rather it is necessary to realise that costs have to be related to the value delivered in a constant manner, and value for money has to identified, to assure that clients get the best possible life cycle value from suppliers (contractors etc.) [7]. However, in current practice, criteria for selection and bid evaluation of contractors are often still aimed at mere project delivery capabilities. For the “living building” concept, a wider range of criteria is needed to evaluate suppliers’ capabilities against the needs of clients and other stakeholders [8]. Thus the procurement system must be linked to the client’s priorities. The priorities and the procurement system are influencing the team selection, and thus the project outcome and performance level [9]. The use of “sound” selection criteria and application of a “best value based contractor selection framework” are essential to achieve the desired project outcome and “best value” [10].

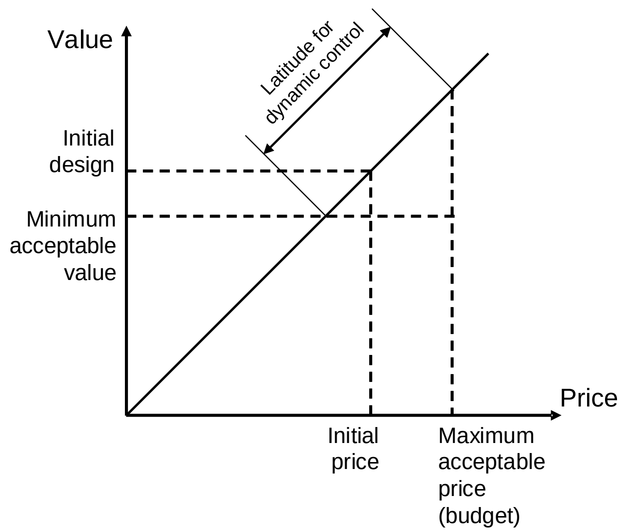

Figure 1: Principle of dynamic control

The ultimate goal is to find the best solution for clients and other stakeholders, as well as the contractor and suppliers, i.e. best value for the client at minimal costs for the supplier. This maximises the benefit; value minus costs. Client and supplier share the benefit by finding a right price in the middle. The goal specificity is influenced by value specificity and the client's requirements. Higher levels of value specificity and observing life cycle value rather than project delivery improve the final project outcome and the starting point for the rest of the life cycle of the built service [11]. In order to specify all stakeholders' values and project priorities, value engineering must be a structural component of the procurement process. Analogously to the procurement process, the value engineering must be performance based, not price based. This implies measuring and rewarding performance delivery, minimizing adversarial relationships and collaborative decision making leading to "best client value" [12]. Besides "value optimization" value engineering must be aimed at target costing, in order to increase and maximise the gap between value and costs, i.e. maximising the total benefit for client and supplier [13]. This kind of "value for money" approach has the largest potential in the early stages of the project, i.e. the briefing phase, when strategic decisions are made, together with application of integrated life cycle contract types [14] [15]. During the value engineering both client and supplier must be committed to invest and use extra budget to develop the design collaboratively based on life cycle incentives within an alliance or partnering arrangement [16].

Negotiation and collaboration have been advocated rather than competition and relying on market mechanisms to achieve best value for money. However, it has also been argued that competitive procurement methods achieve better value for money than negotiated procurement methods [17]. Clients tend towards competitive tendering to get value for money. Contractors tend towards negotiation and longer term contacts to strive for delivering value for money for a longer in the life cycle [18]. Strategic procurement methods, like framework contracts, have been observed to be more effective in particular sectors of construction, where longer term contracts offer specific benefits [19]. Reengineering procurement methods towards more from adversarial relationships to more co-operative and partnering relationships, need to be combined with fully integrated and coordinated design, integrated supply chain management, and efficient managerial control of the whole design and construction process, leading to benefits to all parties [20].

3.2 Supply strategy principles

Current supply strategies in construction are in most cases restricted to project delivery only. Future supply strategies must be extended beyond project delivery, including facility management, maintenance and refurbishment, to assure the functionality and serviceability of the built service. This implies “continuous value delivery” or “life cycle value delivery”, instead of project delivery. This approach requires dynamic control capabilities of the whole life cycle by suppliers of built services. The industry needs to broaden its approach to value delivery, and apply the concept of value delivery proactively vis-à-vis construction clients [21]. In general, the “living building” concept requires that the industry moves from a delivery system within a price based environment towards higher level of “performance based competition” [22].

Industry partners must adopt the use of integral value management through the supply chain to facilitate collaborative working and increased inter-organisational collaboration for resolving current industry inadequacies regarding design, construction and facility management [23]. Integration of the team to the client’s value system is essential to capture client value from the beginning of the project and informing further decision making during the project, and continued value delivery through the value chain [24]. Therefore, contractors and other suppliers in construction must develop and improve their pricing strategies, their costing capabilities and their financial risk management [25].

3.3 Integrated process principles

The “living building” concept must result in the integration of the design, construction and facility management of built services. Based on the awareness that perception and increasing knowledge will influence and affect demand as well as possible solutions during the process, clients and suppliers team up to develop and deliver the built service, based on a common understanding of the demanded value, performance, and how to define value, costs and price dynamically. Both clients and suppliers are no single entities, but often complex configurations of stakeholders, with different value assumptions, interests, investments, particularly in large construction projects, sometimes within a complex political social, economic context. This calls for extended stakeholder identification and involvement to define best value (demand) and deliver best value (supply) [26].

Operation costs of a built service over the life cycle are a multiple of the initial construction costs. Decisions in the briefing stage and the design process influence life cycle costs [27]. To improve the delivery of client best value the contactor gains more control over design and construction, in order to be able to assure the continued value delivery thought the life cycle. Therefore life cycle costs data and evaluation techniques must be linked to design development tools [28]. Then process control can be based on dynamic performance information and continuous output measurement, aimed at total costs minimisation and life cycle value maximisation [29]. For the cost evaluation of choices made through the life cycle, a comprehensive framework for decision-making is needed; ‘a continuum which links the life cycle cost across different stages of the life cycle’ [30].

4. The “living building” future of construction

4.1 From performance specification to output measurement

The “living building” concept advocates the shift from performance specification to output measurement. In current practice, clients often define the performance in the brief at the start of the project and use change orders to alter their demand during the process, even still in the construction phase. Change orders are often regarded as a phenomenon occurring outside the briefing rather than integrated part of the briefing process. Previous authors have proposed the application of “dynamic brief development”; a process to develop the brief allowing change orders until the brief and the price is fixed after a certain period of time during the first phase of the project [4]. The “living building” concept implies a dynamic approach to the brief that goes beyond this in two respects: the brief is kept dynamic until the project is delivered allowing changes from both clients and contractors/suppliers aimed at further improvement of the value and cost level; the price forming process is kept open based on the dynamic brief. The price is established eventually at the end of the project based on output measurement according to formulas that have been agreed upon by client and suppliers.

4.2 From static to dynamic process control

In the “living building” concept, the dynamic briefing approach is extended from the early briefing stage of a project through the design and construction process. This implies that the entire process is managed by dynamic control. To enable integrated dynamic control of the entire process and the supply chain, the interfaces in the design and the team are conceptualised by means of a systems approach that allows to design and evaluate the design holistically, and to monitor and take collective action after things change. In this way, the dynamic briefing process is extended throughout the entire project process. The project brief is the dynamic basis for continually developing and adapting in an integrated manner design and further technical development and realisation of the built service. This requires a control mechanism for development and feedback that incorporates all aspects of the value delivery process and connects all actions by participants to project priorities, and supports information sharing and informed decision-making [5].

4.3 From a project towards a life cycle perspective

The ultimate step of the “living building” concept is the extension of the dynamic approach after project delivery, through the entire life cycle. Clients and users, and contractors and suppliers continue their involvement in maintaining the functionality and serviceability of the built service. The team is involved through a long term contract to take action based on new demands and insights from clients and users, and make alterations and changes to the built service based on new knowledge that improve the usability or cost levels. The performance of the built service is evaluated continually, and decisions to take action are made through the continued measurement of value and cost levels. This implies life cycle alliances to assure the continued involvement of parties and stakeholders during the life cycle. This is particularly complex while after project delivery, alterations and changes to the built service imply reconstruction and refurbishments, which are part of the use and facility management of the service, involving users and facility managers and other parties that have not been involved in the project before. In addition, changes of users and owners through the life cycle make this even more complex.

4.4 Dynamic control for different types of contract

In a certain way, dynamic control is applied in current practice: Suppliers ask a price for the construction of the project as specified by the client. In order to cope with unforeseen events and the associated consequences, additional work due to perception is measured as additional quantities of materials related to the initial design. When multiplied by unit prices these quantities are the basis for supplier’s financial compensation for additional work. This simple measuring system can not used for integrated contracts such as DBMOT, BOT, DBFMOT, as quantities can not be measured due to the absence of a fully specified design of the building. For these types of contracts, the changed value should be measured in another way. For DBM kinds of contracts the changed value due to perception can be measured in performance of the building expressed in measurable aspects such as form (e.g. aesthetics), function (e.g. capacities), technical quality (e.g. energy consumption). For DBMOT kinds of contracts, the changed value due to perception can be measured at a high level by the net present value of the life cycle value. With a fixed relation between the measured value and the price to be paid, dynamic control leads to large benefit for the client and large profit for the supplier. The price development for the three different contract types is shown in figure 2.

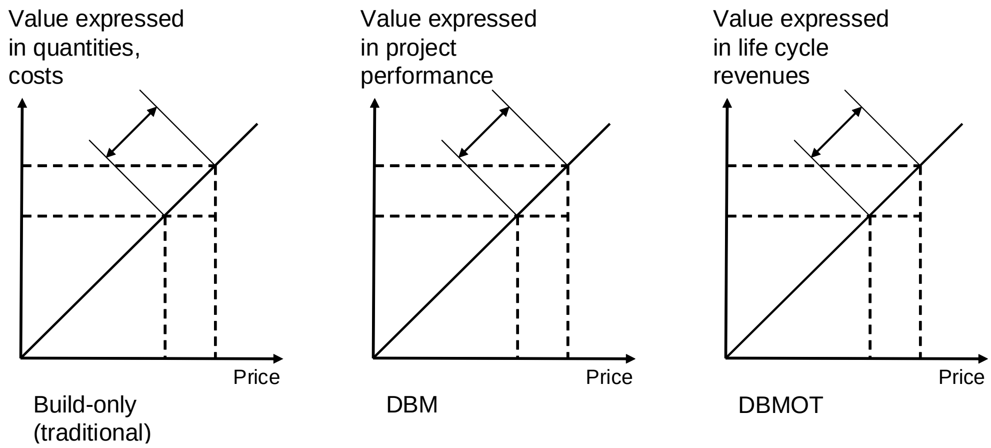

Figure 2: Price development for different contract types

5. Discussion and conclusion

The "living building" concept represents a new and comprehensive approach to demand and delivery of built services, based on a dynamic approach to the construction process and the life cycle. It solves problems of perception and process statics. It offers great potential advantages to demanding parties (clients, users etc.) as well as supplying parties (contractor, suppliers etc.). Particularly the continued dynamic approach, performance measurement and involvement of parties through the life cycle imply a great endeavour for clients as well as suppliers.

6. Further research and developments in practice

Further research and current developments in practice in the Netherlands have been aimed at at the development of the "living building" concept and life cycle contracts, particularly for road infrastructure. Few contracts have already been implemented by the Ministry of Transport, Public Works and Water Management for some roads. These contracts include the maintenance and facility management for a long period of time. The performance is predefined as much as possible, leaving open how the contractor/facility manager takes care of this operationally and technically, but only predefining cost levels and minimum performance specifications. The contractual and operational arrangements of adaptations that may have to be done to the roads in time, and proper corresponding financial arrangements still pose quite some difficulty. Delft University of Technology and TNO Built Environment and Geosciences have been doing and planning research projects aimed at these issues, as part of the national research and innovation programme for the Dutch construction industry PSIB. The research is aimed at the further development of contracts and procurement methods that include effective arrangements for adaptations of built facilities (i.e. roads) during the life cycle as a result of changing circumstances, demands and knowledge, including the definition of corresponding contractual financial mechanisms based on dynamic value-cost calculations and life cycle performance measurements. Results of these research projects will follow in subsequent papers.

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e-Construction – finally taking off?

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Abstract

Various pilot projects on the use of advanced ICTs in the construction sector has demonstrated that stimulating digital integration is a key measure to improve quality and increase the productivity in the construction sector. Especially applications aiming at collaborative working are seen as promising, i.e. software to facilitate cooperation between designers, suppliers, engineers, software developers etc. [4, 5, 6]

Traditionally, the construction sector has been a slow mover in the field of ICT [1] [8], but a number of drivers challenge this conservatism, including increased competition in the internal market, increasingly complex project management and industrialisation. Thus, it could be expected that construction companies adopts a more pro-active approach in this field.

This symposium presents the 2005-results of the largest survey in Europe on the use of ICT in the construction sector. This presentation will explore:

- Recent developments of the use of ICT in the construction sector
- The impact of e-business on the European construction sector
- Comparison of the development with other sectors
- Implications of e-business on construction companies, including SMEs

Keywords: e-Construction, E-business, E-procurement, e-Collaboration, e-Invoicing, Productivity, Integrated IT-solutions

1. The e-Business W@tch

1.1 Overview

As part of the so-called EU Commission initiative e-Business W@tch, Construction has been selected as one of ten sectors to be analysed. The presentation on the symposium will be based on the analysis of the Construction sector conducted within this framework.

Brief presentation of the e-Business W@tch

The eEurope 2002 Action plan provided the basis for targeted actions to stimulate the use of the Internet for accelerating e-commerce, acknowledging that "electronic commerce is already developing dynamically in inter-business trading [...]" and that "it is important for SMEs not to be left behind in this process [...]." The eEurope 2005 Action Plan, endorsed by the Seville European Council in June 2002, confirmed and built further upon these objectives with Action 3.1.2. "A dynamic e-business environment", which defined the goal "to promote take-up of e-business with the aim of increasing the competitiveness of European enterprises and raising productivity and growth through investment in information and communication technologies, human resources (notably e-skills) and new business models".

It is against this background that the European Commission, Enterprise Directorate General, launched the e-Business W@tch in late 2001, with the objective to provide sectoral analysis based on sound empirical research, including annual enterprise surveys in all countries of the enlarged European Union. Special emphasis is placed on the implications for SMEs. [1]

Since its launching, the e-Business W@tch has published e-Business Sector Studies on 17 sectors of the European economy, synthesis reports about the status of electronic business in the European Union, statistical pocketbooks and further resources (newsletters, presentations, special issue reports). These are all available on this website: http://www.ebusiness-watch.org/

1.2 Introduction

The European construction sector includes more than 2 million enterprises of which the majority are small companies with fewer than 20 employees [2]. The construction sector is the biggest industrial employer in the European Union, with a GPD contribution on approximately 10%, an overall employment rate of 7% of European workforce and 28% of the industrial employment [3].

The European construction sector is characterised by a few large design and engineering companies and a large number of small sub-contractors. The role of the large construction companies are changing from pure contracting towards a greater focus on project management. Moreover, they increasingly outsource work to small companies and concentrate to a greater extent on running the projects.

Various pilot projects on the use of advanced ICTs in the construction sector has demonstrated that stimulating digital integration is a key measure to improve quality and increase the productivity in the sector. Especially applications aiming at collaborative working are seen as promising, i.e. software to facilitate cooperation between designers, suppliers, engineers, software developers etc. [4] [5] [6]

The symposium explore to what extent ICT is used today in the sector, where the development is heading and if potentially promising technologies are adopted in the sector. Some of the key issues related to the use of ICT in the sector are:

- Productivity: ICT aimed at controlling projects with marginal profit are important. To what extent are ICT used for project planning, budgeting, controlling of projects etc.? Will ICT increase productivity in the construction sector similarly to other industrial sectors?
- Integration: Integrated IT-solutions, which supports project management and tunes companies to an increasingly competitive market, is an important issue in the sector. Which problems related to IT-interfaces and standards are facing construction companies when integrating working processes horizontally and vertically?
- Cooperation: Production processes are changing internally due to new mobile/wireless solutions and externally due to collaborative software. Which new forms of internal and external organisation are emerging as a result of new ICTs? Are new technologies likely to catalyse a restructuring of the sector?
- European market: Systems for e-procurement and e-invoicing are evaluated and implemented in larger construction companies at the moment. Does e-business stimulate the cross-border consolidation of the sector? Does it promote the establishment of a single European market for construction services?

1.3 Findings

The construction sector today is characterised by a large degree of fragmentation in IT usage. [2] [8]

- A multitude in standards, technical specifications, labels, and certification marks as well as diversity in local, regional and national legislation and regulations.
- A low adoption and integration of relevant ITC in most business processes – especially with SMEs that are often characterized by communication and knowledge sharing based on personal contact or telephone.
- High sensitivity to changes of economical conditions in market and society.
- Companies are typically either organized around projects and project flows or suppliers to project managed companies.

The following trends also set the stage for further uptake of ICTs in the sector:

- Increasing pressure for consolidation
- Industrialisation based on new concepts, e.g. pre-fabricated houses
- Outsourcing and specialization

- Internationalisation including new market opportunities and increased competition from foreign players

<u>E-business activity</u>

The attitudes towards ICT in the sector have traditionally been of a conservative nature. Apprehensions towards ICT investments are still strong and most companies are re-active rather than pro-active in the usage of ICT as a tool for competitiveness. [2] [4] [5]

Four topics can be recognised as important drivers for the development of electronic business in the Construction sector. These are productivity, integration, collaboration and the European market:

Productivity in the building and construction industry has yet to show the same level of productivity improvements as other industries including production. This has to do with the line of work and the type of production involved in construction processes but it also has to do with a slow ICT uptake in a sector dominated by small and medium sized players. Large enterprises in the industry as well as new sector entrants have adopted ICT based production improvements, but there is still un-used potential for ICT uptake in the area of productivity, e.g. with production planning systems, ERP-systems with financials, MRP system, Inventory management systems, CRM-systems, SCM-systems and Mobile solutions.

Integration is an important driver for developing ICT in the Construction sector. Many companies have a low degree of integration of both internal and external business processes as most companies in the Construction sector organise work around unique construction projects leading to fragmented business processes supported by "home made" ICT systems that do not integrate across the basic ICT landscape of the company.

SMEs in the sector are especially behind on system integration – also compared to other sectors. However, new sector specific solutions for smaller companies are being developed and ICT vendors take a growing interest in the market.

Collaborative systems are important as the construction industry is characterized by bringing together many different organizations dependant on coordination and cooperation to complete a shared goal. Effective systems to distribute and share information are a critical precondition in order to raise productivity and manage resources and costs, and potential benefits and savings enabled by improving interoperability and implementation via digital solutions are extensive. But implementation of collaborative systems is hampered by a number of barriers ranging from form lack of shared standards for information exchange to technical limitations, social and cultural issues.

ICT as a means of creating a European market in the building and construction industry is limited by the location bound nature of construction. However, e-procurement (e-tendering and e-ordering) as well as e-collaboration (e-communication and e-SCM) can contribute to the creation of a European market by making the market more transparent and by facilitating communication and coordination across borders.

In the future new solutions and increased uptake can be expected in five areas:

- Platforms for collaboration between the many partners in consortia, mainly by project webs where drawings etc. are shared. This development will be facilitated by increased standardisation of information on building projects.
- Integrated ERP solutions will be developed further focusing on the main business processes of project management, risk management and resource management. As standard industry solutions become available at lower prices, more SMEs will begin to adopt such solutions.
- The large project driven firms (consortia leaders) will adopt e-procurement as a means of reducing costs
- The increased industrialisation driven by new concepts and increased internationalisation will be supported by e-SCM (systems for supply chain management)
- As reduced margins drive business models to focus on services, industry ERP-solutions will include management of services, e.g. facility management. Other construction companies will expand into project development (e.g. developing plots of land into housing and selling or letting the buildings instead of just building them) and look for IT-solutions that support this.

1.4 Methodology

As in the previous years, the e-Business W@tch 2004-2005 use internal as well as external sources to collect not only data and indicators but also background information about the sectors covered. The different types of sources and the information they deliver constitute the main input for the sector reports. These sources are complementary to each other. The nature of information to be extracted can be qualitative or quantitative. Qualitative information (e.g. from case studies, or as provided by industry associations) will mainly serve as context and have an explanatory function, while quantitative data gathered through primary research (mainly via the e-Business Survey 2005) will deliver the e-business indicators and the sector statistics for reports. [1]

- Desk research (secondary sources) will be used to identify business examples, background information about trends and e-business developments in the sectors, and as pointers to potential case studies which can be followed up.
- Primary research will be used in form of the e-Business Survey 2005 and for collecting new case studies on e-business.
- In addition, the e-Business W@tch will continue to use industry statistics obtained from the Eurostat New Cronos database. However, data from this secondary source will be

processed and refined as necessary in order to close gaps (for specific countries or years) as good as possible.

The e-Business Survey 2005 is a cornerstone to this initiative, as it is a key instrument to collect e-business data on sectoral level which are not otherwise available in this structure and coverage. The survey also represents an important cost position in the project. As in 2002 and 2003, the survey is carried out as a CATI survey and cover all 10 of the sectors selected. The survey provide aggregated data for the European Union as a whole.

The e-business indicators (questionnaire)

The questionnaires used in the e-Business Survey 2005 is based on a conceptual framework for the measurement of ICT adoption proposed by the OECD, namely to at "readiness, activity and impact".

"Readiness" translated into ICT infrastructure diffusion and the development of accompanying skills. "Activity" was defined as e-business processes between enterprises and their customers, suppliers and cooperation partners, as well as internal business processes that are conducted electronically. "Impact", which is still the most difficult area to be translated into survey questions that can be directly asked to interviewees, was dealt with by asking companies about the perceived consequences of their e-business activities. In addition, in 2003/04 the relationships between innovation activities of firms and the level of their e-business activity was investigated, which presents a more complex and sophisticated approach to look at possible implications and "impacts" of e-business.

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Forgiving Technology in Automated Office Buildings

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Abstract

A smart control device with an additional tool box which includes educational and information kits, called forgiving technology, has been developed in the EU funded project EBOB (2002-2004). It is meant for personal computers of the office workers enabling sustainable office working environments based on user behaviour. Careful design of the new prototypes for smart control devices has been accomplished with usability studies in different working environments in Sweden and in the Netherlands.

Promising results of the effect of the forgiving technology on the end-user behaviour are expected, which can result in ever more sustainable office buildings in the future. The possible changes in the office workers behaviour, which improve energy-efficiency are discussed in the paper. They concern both new office buildings and renovation projects.

Keywords: Office buildings, building automation, forgiving technology, end user control, energy saving, motivation tool

1. Background

This paper is drawing much from the EU Fifth Framework project EBOB, Energy Efficient Behaviour In Office Buildings (NNE5-2001-0263). The key focus of the EBOB project (www.ebob-pro.com) is on the combination of the human and social perspective with advanced modern control and ICT (Information and Communication Technologies) solutions. This is done in order to make energy efficient behaviour natural, easy and intuitively understandable for the end-users, and at the same time to achieve the most energy efficient solutions while improving standards on indoor comfort in refurbished and new office buildings. The results gained due to this combining approach of human perspective and available new technology are called 'forgiving technology'.

The EBOB project creates new technical and socio-economic solutions to make energy efficient behaviour natural, easy and intuitively understandable for the end-users in refurbished and new offices. This will be achieved by starting from human perspective and use available and new technology (including ICT, smart control, user interfacing).

All energy use in a building interacts with each other in different ways. The focusing points in motivating the use of energy efficient solutions can be: information, user behaviour (end-user satisfaction, personal motivation), productivity, health aspects, indoor climate and tools (control systems and user interface). In this paper the building automation tools to be used to make the office space better regulated by the end-user and the end-user better informed of the influences of their acts are discussed. The more new knowledge is available the more productivity, health and indoor air aspects are talking for the need of flexible, adaptable and well regulated workplace and workspace. Furthermore, workers want to feel comfortable when working. The joy of work is gained out of empowerment, which forgiving technology allowing personal control is about. They are the basis for developing and using forgiving technology, but discussed in more detail in other context. First, this new way of controlling is introduced.

1.2 Definitions

Building automation is related to the phenomena of automated and intelligent buildings, which sometimes are mixed. There is no universal definition of intelligent buildings. However, certain consensus of the intelligent building concepts exists and efforts for agreement of the definition are available (cf. e.g. [4] and [18]). The latest of them is available of the automated buildings (Technology Roadmap for Intelligent Buildings, 2002). Also the ranking lists for the automated buildings are under development by the efforts of the CABA (Continental Automated Buildings Association, www.caba.org).

To differentiate intelligent buildings from other building concepts the forms of building intelligence[1] have been studied ([10], pp. 284-342). The forms of Building Intelligence (BI) are

[1] *Building-connectivity* (speaking and speech recognition including music and linguistics; user-connectivity and control: either personal or automatic or defined by the organisation in concern); *Building self-recognition* (building knows the state it is in; a kind of consciousness); *Spatiality* (a more conscious understanding of the spatial expression of the architecture, structures, interior design); *Building kinaesthetic* (a sense of change, active structures, moveable structures, furniture and equipment, adjustable technology or building services), and *Building logic* (embedded sensors to monitor the occupants' daily activities, combinativity).

derived from the forms of human intelligence[2] [11]. Automated or integrated buildings are intelligent buildings, where logic is the key attribute of the design, and the human ability of mathematical and logic intelligence is the motor for the solutions. Building automation is the leading application for this form of building intelligence. The other forms of building intelligence assist in making the building logic work for the benefit of the building occupants and occupant companies. Such assisting factors of intelligent buildings are (1) inter-connectivity by user interface (cf. also [12]), (2) building recognition which means that the building is aware of the status of building services and occupant activities, (3) spatiality which is related to the right locations of the building automation control units, and (4) the existence of active structures which make the building control come true.

Sustainability covers both the ecological issues and the human welfare. That is why the EBOB project and the development of forgiving technology have much to do with the Green building concept, which is also lacking a universal definition. Green buildings are according to the U.S. Green Building Council (USGBC), buildings that are environmentally responsible, profitable, and healthy places to live and work in (http://www.usgbc.org/). Furthermore, there is the concept of Healthy buildings, which is the continuation of the research of Sick buildings. The Sick building syndrome has been a concept to study phenomena of indoor air quality which affect people in a negative way causing syndromes such as back or head ache, irritation in throat or nose, difficulties with vision, etc. In healthy buildings indoor air is supportive to human health condition, abilities and activities.

1.2 State-of-the-art of Office Building Control

The need for energy renovation is urgent in such older office buildings where not only the envelope and the structures need repair, but also the control of HVAC systems is lacking. The change of the end-user behaviour can be an alternative strategy for reaching energy savings and still avoid high renovation costs. In the new office buildings that have been built by following the latest knowledge of the energy efficient and sustainable building technology and with the latest control technology, the correct energy efficient end-user behaviour is the only way of letting the technology prove its efficiency.

The end-user behaviour can be changed even without technology by informing and motivating. The automated control technology saves trouble caused by manual operations. However, still

[2] Seven forms of human intelligence by Gardner (1983 in [8], pp. 120–123, 1991 in [8], pp. 345–352, 1993 in [21], pp. 107–110, 1993 in [7], p. 28) are: Logical-mathematical, musical, linguistic, interpersonal, intrapersonal, visual-spatial and bodily-kinaesthetic.

personal involvement might be needed for special occasions or for personal needs differing from the standard norms of indoor climate.

1.3 Need of Personal Control

It is common knowledge among facilities managers that the possibility to influence one's work environment is one of the most important factors of the workspace design. A second one is the feeling that problems are taken care of, in one manner or another like change, repair, etc.

According to "What Office Tenants Want, the 1999 BUMA/ULI Office Tenant Survey Report" only 56 percent of all respondents are located in buildings with any of the intelligent features listed in the survey[3]. The questionnaire was sent to approximately 20,000 office tenants throughout the USA and Canada. Slightly more than 1,800 responses were received, primarily from principals or owners, executives, office managers, or department managers of the responding companies. Intelligent building features are much more prevalent in owner-occupied buildings ([24], p. 50).

In tenants' rating of the importance of intelligent building features to their business, but not currently available in their building no single intelligent building feature stands out, but six features are consistently among tenants' top three: high-tech and energy-efficient HVAC system, wiring for Internet access, wiring for high speed networks, LAN and WAN connectivity, fibre-optics capability, conduits for power/data/voice cabling ([24], p. 42). Automatic on/off sensor in the lighting system was not among the top six. The priority of the features changes when the tenants were asked to indicate whether they would be willing to pay additional rent to have those features: computer-related features, high-tech and energy-efficient HVAC system, security systems, telecommunications capability, and redundant power source ([24], p. 44).

The relatively high ranking of HVAC systems in this corroborates the importance tenants place on having a comfortable temperature in their office and having control over the office temperature ([24], p. 43).

[3] Fiber-optics capability, built-in wiring for Internet access, wiring for high speed networks, LAN and WAN connectivity, satellite accessibility, ISDN, redundant power source, conduits for power/data/voice cabling, high-tech and energy-efficient HVAC system, automatic on/off sensor in the lighting system, smart elevators that group passengers by floor designation, automatic sensor installed in faucets/toilets, compurized or interactive building directory

- According the IBs Survey, carried out in Finland in the Helsinki metropolitan area in twelve office buildings, the possibilities to control room temperature and lighting were not particularly good. They were evaluated with no high rates; room temperature with mean rate 6.2 (n[4]=455) and lighting with mean rate 6.7 (n=455) ([10], pp. 242-243). The index was from 4 to 10, which was the best. In general the building and office automation was rated with 7.9 (n=286) in the intelligent buildings and with 7.5 (n=182) in the other high quality office buildings used as reference buildings to the intelligent ones ([10], p. 208). The respondents' evaluation was based on the effect of the building feature to the working efficiency. In this Finnish survey, there was found a statistically significant difference in the quality of technology between intelligent and other types of office buildings in whole, when all rates were summarised. However, this correlation was not found on controlling possibilities. The control was not better in the IBs than in other office buildings, although in some cases good personal control possibilities of indoor air had been in focus in the design of IBs.

The IBs Survey proved the work environmental control possibilities important, while those who had the chance to participate in design of their work environment evaluated the quality of it better than whose who could not, or had difficulties in influencing the design ([10], pp. 264-267). Besides, the majority of the respondents (60.4 per cent) could not even participate in the design.

Wyon (1999) states that no improvements in sustainability will occur unless users are provided with insight, information and influence. Insight includes an understanding of the context in which the behaviour and its consequences occur. Information includes feedback on current conditions such as room temperature and energy use. Influence includes providing means of affecting the relevant variables such as a user friendly, intuitively understandable user interface enabling users control of indoor climate parameters on the office room level.

The office workers and the facility management have to be involved for effective use of technology. Commitment and encouragement of the office workers and facilities managers to promote sustainability, and prevention of misbehaviour in use of technology are seen among other benefits yielded from technology as a new potential for even better energy efficiency in commercial buildings. It is not even enough to provide motivation in the form of rewards or sanctions. Occupants must also be empowered to adapt modified behaviour.

[4] number of respondents

2. Forgiving technology

Practice shows that many technical solutions for energy saving exist and are installed in many office buildings, but the real energy saving effects are not there. Reasons for these deviations can be found from: wrong combinations of building and installation technology; misinterpretation of operational staff; misunderstanding and energy inefficient behaviour of the office occupants [5]. The overall aim in the EBOB project is to save energy by:

- Integration of and interaction between behaviour aspects of office workers and energy saving technologies
- Prevent wrong combinations of building and installation technology
- Prevent misinterpretation of operational staff
- Prevent misunderstanding of office users
- Prevent energy inefficient behaviour of office users
- Produce (energy saving) systems, that seduce people to participate in energy saving behaviour
- To guide the design process towards energy saving solutions that considers human behaviour.
- Design guidelines.

2.1 Need of End-user Involvement

The work done in the EBOB project has resulted in the conclusion that a major factor explaining the bad energy saving results in office buildings is that users are misunderstanding how the HVAC systems work, e.g. not seeing the relationship between lowering temperature and raised energy use during Summer conditions and on the other hand the relationship between high indoor temperatures and raised energy use in Winter. Information of the effect of personal behaviour on the energy use of the building where the end-user is working is expected to result in less energy use.

Also, office workers are not always aware of the correct use of the control equipment, which causes energy losses. A user-friendly technology with informative control alternatives – the forgiving technology created by the EBOB project - could solve this problem (Figure 1).

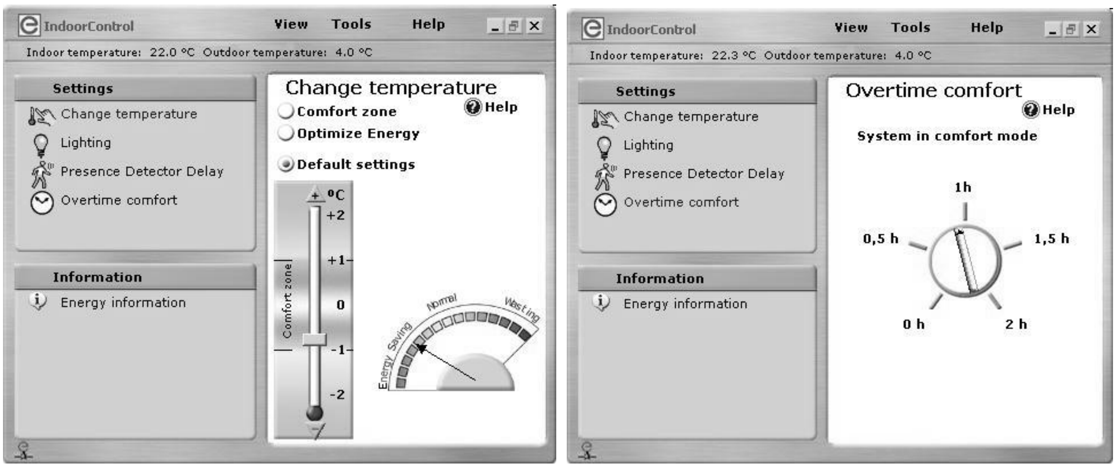

Figure 1: The control unit for forgiving technology. (TAC)

2.2 Technology

To allow the lowest energy consumption it is necessary that the building permits energy saving. A good starting point for energy optimisation of a building is that the building in itself is designed in an energy efficient manner.

In the modern office indoor environment the control of the room temperature, lighting and office automation equipment affect the energy consumption the most. In the EBOB project the work has been concentrated on the temperature and lighting regulation, and their co-operation. The temperature control involves heating and cooling and the lighting control includes the control of Venetian blinds. The system is generic and adaptable for other solutions in the future. The office automation as well as lighting is becoming energy-efficient. The energy losses from them or the use of free energy out of them will be reduced in the future.

Workers are a source of free energy. The occupancy of the office spaces varies during the working day. Working culture and the line of business influence the occupancy too. Occupancy has been discovered to be rather low for example in Northern American and English working cultures and higher for example in Finland. In England the occupancy can be as low as 45 % ([25] in [17], pp. 25) and in USA 33 % ([9] in [17], pp. 25). The occupancy of executives and executive assistants is 30 % and that of secretaries 60 % according to the British workplace consultants of DEWG [6]. However, Brill and Weidemann report higher occupancies in USA; managers 78 %, professionals 82 %, engineers and technical 80% and administrative 86 % (2001). According to the IBs Survey the occupancy of the Helsinki metropolitan offices is 87 % (62 % of the working time is spent at personal workspaces and 25 % in other spaces in the building) ([10], pp. 213, 228-231), and the occupancy of 67 % was found by Nissinen in Finland (2003, pp. 66). On the other hand, in the Netherlands the occupancies have been discovered to be low; 60 % of the office workers are in the office, and 35 % present at their personal workspaces [20]. The presence detection is the tool to take the occupancy into account also in the EBOB project in addition to the end-user motivation to prevent energy losses to reduce unnecessary heating and lighting of empty spaces.

The indoor air quality is out of the scope of EBOB project, although the standard of it might have influence on the need of energy for ventilation. However, the regulation of the heating and air-condition systems done for keeping up the comfortable indoor air temperature affect also the indoor air quality; odours, particles, etc.

A set of EBOB rules for installations have been defined including the temperature control set points, heating and cooling operation times, etc. They are based on the data of the most effective heating and cooling periods of office buildings around the clock, use of heat recovery, new theories of the use of outdoor air temperature for dimensioning, etc.

The building manager chooses the buildings' temperature set point value. This set point can vary during the seasons and should be easy to change. It can also vary how much flexibility the building manager want to give to the users in the aspect of how many degrees of centigrades they should be able to change the temperature. The set-up of the steps a user should be able to change has to be done as well.

The EBOB solutions may include equipment with specified functionality and performance. It is important that these requirements are made clear so that the right type of equipment is actually purchased by the subcontractors, and not replaced by lower functionality or lower performance products. E.g. the contractors should be educated in these questions after signing the contract.

2.3 User Motivation

Influencing the behaviour of the actors can be done by; a) investment in energy efficient equipment (e.g. insulation, energy efficient equipment), b) more efficient management (e.g. thermostat setback when the office-worker leaves her/his room) and c) curtailment of needs or comfort. The multidisciplinary approach to workspace design and energy-efficiency is needed, because only rarely one idea alone is strong enough to solve several problems at the same time. Also the humble ideas of not knowing all – or even the possibility of not ever being able to cope with all phenomena of energy efficient workspace design – might be useful in design, in particular in the era of demand driven knowledge workplace design. For successful implementation of forgiving technology a supportive energy-efficiency of the building environment in the terms of the life-cycle of the building is needed.

Control is about possibilities and limitations [22]. The limitations of control can be classified in two main categories: external limitations and internal limitations. When actors experience that they have external limitations they can believe for example that they cannot regulate the energy consumption of their room. External limitations are:

- The action is under the control (or responsibility) of other actors
- Economical limitations
- Limitations of social or work-related roles
- Time limitations
- There is no (realistic, good) alternative
- Lack of tools available
- Lack of information available.

When actors experience that they have internal limitations, they believe that their behaviour is not under their free will but under the control of an internal force. They are:

- Psychological aspects (personality, addiction, habit, lack of motivation)
- Cognitive aspects (lack of knowledge, biased mental models, lack of skill, has not thought about the issue before).

Motivation is based on the human tendency to use intelligence for the benefit of oneself and for satisfaction of one's needs, which can be described by the Maslow's Hierarchy of Needs according to his latest work [13]. A good environmental design cannot forget details that can clinch on the success or the fiasco of any solution, and an energy efficient forgiving technology respects the human needs, either separately each of them or in relevant combinations. There are a few interesting phenomena influencing the R&D work of products, which can be derived from the hierarchy of needs [12]:

- The human desire to easiness allows the automated functions.
- Variety of lifestyles makes the possibility to switch on manual mode necessary.
- Because of the need to know, occupants want to know what the automation is responsible for and what happens when a certain sound is heard or other activities take place.
- Such a human need as self-actualisation in the modern times goes hand in hand with the growing individualism influencing the design and research and technical development.
- Everybody wants to be good. A desired product provides the client with such an added value, which makes it possible.

To involve the service technicians, they need to be engaged in the creation of a new system. The main part of the life-cycle of a system is during the services and maintenance, after an installation is made. Often developers forget this and adapt the system to be easy to install but not to maintain. We can see the system as a combination of different modules and each module needs to be administrated and maintained.

By choosing this method of working we will get continuous feedback also from the service technicians on how the functions work and if they are easy to maintain or change. Good input can be given by them since they are used to work with different user interfaces and can pick the best pieces from each.

Commissioning of the installation system when the building is first used is a very important factor that can influence the energy use and comfort. It is important that the service technicians receive sufficient and correct information and training. The user interface should therefore be intuitive to minimise training.

Still, the knowledge of the state-of-the-art of building is valuable for those in charge of the energy costs and the comfort level of end users is valuable information for the human resources departments of the occupants companies, and the future design of the control systems. The possibility to transfer that information further to those in need is a mean of improving motivation among FM personnel.

The motivation of the building owners and providers emerge from such company goals as [14]:

- the matter of interest in developing the relatively traditional building sector with acceptance and understanding of knowledge and means how to embed new and radical technology
- to polish the image of the companies working in the fields of building automation and building parts and products with a sustainable or energy-efficient technology
- the understanding of the business of buildings as a form of advantages input to the core process of a the occupant companies
- the interest in gathering end-user feedback (cf. e.g. [16]), and the consideration of the satisfaction of the user needs as the best business opportunity, because the problems of the client are solved
- correct information of the cost competitiveness of intelligent energy-efficient products without over estimating the R&D costs, etc.

2.4 User Interface

The control unit of the forgiving technology of the EBOB project has been designed using expertise in psychology, usability, industrial design and functionality (Figure 1). It resembles the manual control panels for heating and ventilation, but it is run on the screen of a personal computer. In addition to the user friendliness of the control activities the forgiving technology is developed to give information to office workers to make them more aware of sustainability and motivated to behave energy-efficiently. Given information are of three kinds:

- General tips and knowledge
- Specific characteristics for this building
- Real-time feedback in the user interface.

Such factors that are related to the thermal comfort as clothing, so called climatisation[5] during longer warmer or colder periods or due to seasons will be taken into account with the information which will be given to the occupants via the user interface, as well as by education, energy saving campaigns and the EBOB toolbox.

Information and knowledge is only of real value in the process of decision making if it is Just in Time and Tailored to the demands of the end user. Most information systems fail because of the end user gets too much or irrelevant information. This means that the user has to be clear what his interest really is and for which purpose he or she needs information. In the EBOB InfoDoc, this will be solved by a users profile to be filled in before the request of information. Information about the person, interest, professional role, building phase and the organisation and the building will be required.

Such motivators can be mentioned [22] as:

- Comparisons with other's energy usage
- To see one's status compared to the average usage is useful
- To see one's status compared to one's earlier usage
- To display the usage in a graphical or in another easy-to-understand format,
- To display the energy usage in comparable terms which are easy to understand i.e. number of trees that can be saved by the energy savings etc.

Information and notes about energy usage should be short, practical but not too obvious. There also should be a link to further background information (e.g. scientific validity information). The energy related information should be shown already on the page where the users set the temperature so that it is up to the user to decide if he wants to perform the action or not (and not after doing it).

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[5] with climatisation is meant the process while human body adapts to warmer or colder climatic condition either when moving to a warmer or colder climate or during spring and autumn

The system has to be able to give each type of user the appropriate information and steering option based on situation, role and authorisation. E.g., the office user will only see a certain portion of the information relevant to them in the "Information System" while the technician will be able to go deeper into the information, even read the manuals for the hardware etc.

3. implementation

The forgiving technology has been tested in a lab-environment at TNO in Delft in the Netherlands and in an office building of Kärnfastigheter in Helsingborg in Sweden. The rooms with and without forgiving technology are tested and compared (Figure 2). The evaluation of the tests has given feedback to the development of the prototypes of the forgiving technology.

The test results are also input to the activities of a simulation model and calculations which predict the success of the new technology under development. The calculation instrument of the energy consumption in one office building includes all kinds of influences such as sun, outdoor climate, design of the building, installations etc. The user of the instrument can define packages of all kinds of energy reduction measures.

Figure 2: The test room installations. For the end-users' convenience the control of the heating fan coils and the lighting and their different combinations are in focus in the design and testing of forgiving technology.

The classification of the problems implemented [23]:

- Catastrophic: Can lead to a situation where the user has to suspend the use of the product. The problem is catastrophic when it prevents the user from completing his task, causes distortion of information or when it is related to a crucial function. Has to be eliminated.

- Severe: Significantly disrupts the efficient use of the product or slows it down remarkably. Prevents the learning of its functions. Should be corrected.
- Major: Moderately disturbs the efficient use of the product or prevents the efficient use of a limited part of the product. Recommended to be corrected.
- Minor: Disturbs the efficient or fluent use of the product to some extent, generally however within a quite restricted situation. Worth correcting if it is not too difficult.
- Cosmetic: Doesn't directly affect the use of the product, but it might affect the user's experience about the reliability and convenience of the product.
- Technical Problem: A feature of the prototype or a programming- or functional error discovered during the usability assessment, which affects the usability of the product. Is likely to have to be corrected before the implementation of the product.
- User Expectation: User's wish for something generally to be added, but isn't really a usability problem.

In an ideal situation, the occupant's role in controlling energy use and indoor climate is overridden by the system in all aspects except for those in which they need to have the control. It is ideal because it would optimise the comfort and energy use, and at the same time the users do not have to worry about issues they do not want to be concerned with. Expert knowledge gives as an example of this the occupants disability to perceive or not wish to influence normal changes on humidity or air quality parameters as carbon dioxide levels.

However, there are some parameters or installation aspects that cannot be completely automated, parameters that the users want and need to control at least in some aspects [23]. These are:

- Indoor temperature (in a range of a few degrees),
- Lighting (can be partly automated),
- Being able to keep doors and (and in some cases) windows open and
- Shutting down the computer (can be automated in some cases).

In conclusion, these above mentioned situations are the most important cases where the incorrect uses are relevant [23]:

Misuse of temperature controls; four main reasons why the temperature is not always good enough:

- The temperature controllers are too difficult to use and understand.
- The natural feedback (the actual change in temperature) is delayed.
- People have wrong mental models about good indoor temperatures.

- The space is shared (e.g. open office space or a meeting room)
- Incorrect use of lighting, doors and windows, and the personal computer.

The common wrong mental models about the indoor temperatures and air quality are typically the following [23]:

- Most of the people seem to think that a good indoor temperature is always the same independently of other conditions (e.g. season).
- Some occupants think that comfortable indoor temperature is higher in the Winter than during the Summer (which is completely opposite of the reality).
- Many people think that a good temperature is always somewhere between 19-21 degrees of Celsius, which is often uncomfortably cool during the Summer times.
- The users want to change the temperature, or maintain it constant, it may be difficult if they have a door or a window opened.
- The outdoor air quality is also some times worse than the filtered indoor air, which is not always understood by many occupants.

The problem of shared spaces is inherently very tough issue to solve, because all individual preferences and differences cannot be matched. However, the problem is bigger, if there are temperature controllers available. This can produce constantly changing temperatures, if different occupants are often trying to change the temperature according to their own preferences. This kind of situation is uncomfortable for all occupants. It is probably recommendable that in shared spaces the temperature is automated according to the average preferences. In that case at least the majority of the occupants are not complaining. The rest of the occupants might be educated to control their thermal comfort by clothing.

Similar arguments can be found from lighting control as well as myths about computers and energy consumption 1[23]:

- One typical myth is that putting the light off and on too often consumes more energy than it saves.
- It is quite misleading to believe that shutting down the computer shortens the life span of the hard disks in general or shortens the life of the common hard disks.

The potential of computer energy saving settings depends on the computers and on the software used. The existing potentials are not often used because of a lack of time, knowledge or interest.

4. DISCUSSION

It is only recently that smart control technology for better indoor air quality took place, and now it is there for both better indoor air quality and better energy efficiency in buildings. In addition many papers claim that well being and productivity are related to indoor comfort and individual controllability if only without any exact measurements of the effect of them over productivity ([1], Farshchi and Fisher in [3], p. 60, [10], p. 264-268.).

The IBs Survey shows that the office workers (in 1994) wanted to have a building manager to help with facilities management rather than building automation systems (Table 1.).This is challenging for the R&D and testing of forgiving technology. Is current building automation technology able to please the customer needs in the office work environment?

The EBOB forgiving technology is an interactive system with several optional control possibilities, which are very different from fully automated systems dominating the end-user. Unknown in this phase of work when the last year of the three year project is left, is if the interaction between the end-user and the control technology can be used in the indoor air and lighting control satisfactory enough in the end-user point of view.

Table 1:. Man or machine the IBs Survey by VTT in 1994 [15].

Percentages of the respondents, n=514 (office workers)	**Favouring manual operation**	**Favouring automated operation**	**Both**
Text editing by secretary or text editing programs	27	71	2
Copying by a service or from personal computer	37	61	2
Information transfer in meetings or by phone, by emails and via video-conferencing	37	54	9
Image handling by draftsman or image handling programs	37	57	6
Information service by informaticians or from databases	42	51	7
Secretary answers the phone or use of answering machine	70	28	2
Education by personally attending seminars or by interactive multimedia	84	11	6
Building management by building managers or by building automation	**92**	5	3

5. Conclusions

For the time being the conclusions regarding the development and testing of the forgiving technology is based on the first version of the prototype. New software is now running in the test sites and the user feedback from the second prototype of forgiving technology is expected in summer 2004 for more evidence and indications. So far the results are very promising and the belief of the project participants is that the empowerment of the end-users with forgiving technology as developed in the project gives substantial benefits both in terms of savings of energy and more motivated and productive users.

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Evaluation of proposals for PPP-projects from the perspective of the rational consumer

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Abstract

This article analyses the evaluation process of public–private-partnership (PPP) projects from the perspective of a group of rational consumers. This is done by analysing a specific case study and examining how the evaluation process acts and how it affects the criteria, when public private provision is changed from the purchaser/provider model to the community service model so that the focus of the service is on the end-users instead of the relationship between purchaser and provider. The result of this article is the framework of the evaluation criteria of proposals for PPP projects, based on the advantage of the end-user. The proposed framework offers both the public sector in its role of purchaser and the private sector in the role of provider a new perspective for developing PPP-projects that are more valuable and innovative for both parties.

Keywords: Public Private Partnership, PPP, BOT, evaluation process, evaluation criteria, rational consumers, end-users, value for money.

1 Introduction

Viewing public services from the perspective of the end-user has received too little attention. One tool for improving this situation is the public private partnership (PPP). Traditionally, analysing the development and research work related to the mutual efforts of the private and the public sectors to provide public private service has been based on the purchaser/provider model. The purchaser/provider model is particularly evident in the building and real estate industry and research related to this field. In the purchaser/provider model, the end-users, independent consumer groups and associations have been acting in the role of “watchdog”, to protect the public’s interests [1]. Nowadays customer-orientation is widely considered to be the key to improving the quality and efficiency for ensuring and modernising the provision of welfare services. This means shifting away from the producer and administration-orientated thinking and from the purchaser/provider model towards a process of public services that is customer-orientated in their provision and organization. [2]

The aim of this article is examine how the method of evaluation works when the procedure for public private provision is changed from the purchaser/provider model to the community service model, and the focus of the service is the end-users instead of the relationship between purchaser and provider. The goal is to answer the question; what are the elements of the evaluation criteria to be considered when the PPP-model service production is assessed from the perspective of the end-user?

This article is based on a theoretical framework that reflects the end-user perspective of public services, i.e. the community of individual consumers in PPP projects. An evaluation process in action is considered with a case study of a PPP-project, where the focus of analysis is on tendering documents and evaluation criteria.

Chapters 2 and 3 are elaborated on the basis of the author's previous studies presented in, e.g., the Finnish article "Julkis-yksityinen yhteistyö rationaalisen kuluttajayhteisön näkökulmasta" [3].

2 Consumer community as a customer and end-user

The objective of a public-private-partnership is a cooperative arrangement between the public and private sectors to mutually produce services to a third party – the end-user. The public sector is responsible, amongst other obligations, for providing statutory services to the nationals of the state [4]. As the government in Finland is responsible for the entire public policy of the state, local and regional authorities (municipalities) have traditionally been considered to be in the best position to ensure that the statutory-service objectives were met at the local and regional levels of government [5]. Whether the participation of the public sector in service provision is based on law or voluntary action, the provision of services is dictated by current obligations, and benefits of the society constitute the market of public services for members of the society. Within this market, the consumer is expected to act as in the private market, where the consumer aims to fulfil his needs through consuming.

In the past, public service provision has been closely linked to decommodification [6], in other words, equal service provision for all members of the community [7]. This has led to a situation in which the consumer community was considered as a homogeneous (X=Y=Z) group of end-users whose needs have been viewed as consistent. Today's post-modern thinking, however, promotes individualism which recognizes the diverging needs of individual members of the community. As Bauman says, the changing needs and lifestyles of individual consumers affect the formation of one's identity, which is strengthened through consuming [8]. In accordance with this thinking, the community of end-users is actually a far looser heterogeneous (X≠Y≠Z) group of consumers with different needs. The purpose of the public sector is not to directly monitor psychological changes in consumers or to predict their future needs, but to meet the existing demand. It is, however, in the interests of the consumer community if the public sector takes advantage of service provision models which can, with optimal flexibility, adjust service provision to reflect the changing demand.

The following figure illustrates public private service provision in a process based on the purchaser/provider and the community service model.

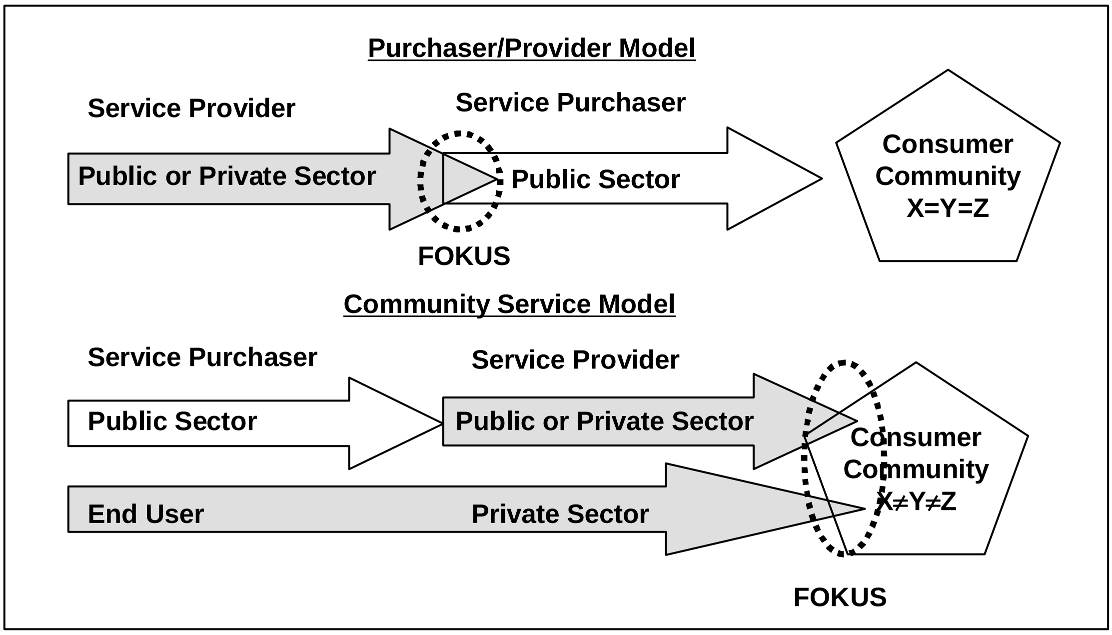

Figure 1: The community as the customer in a Public Private Partnership.

The focus of the purchaser/provider approach, previously used with relation to the PPPs, is on the interface between the provider and the purchaser. Less attention is given to the end-users, who are seen as a homogeneous community of consumers. In the purchaser/provider model, the provider can be a public sector unit or a private body. The purchaser is a public sector unit, representing the end-users. No actual customer relationship is formed between the service provider and the end-user, as the end-user cannot influence the content or scope of the service.

Service provision that utilizes the community service model is carried out through a private or a public unit or through the cooperation of the two. The purchaser of the services is the public sector or a member of the community, the end-user directly. When the purchaser is the end-user and the provider the private sector, the public sector has no role in the process. The customer, and thus the end-user of the services, is always a member of the consumer community, a resident of the local or regional authority or a national of the state. The focus of service provision is on the interface between the heterogeneous group of end-users and the service provider, where the customer relationship is also formed. In service provision models that are based on the community service approach, the possibilities of reacting to changes in the needs of consumers are better than they are in the purchaser/provider model, thanks to the direct customer relationship. Creating a true customer relationship is also an important step in shifting from the earlier provider and administration-orientated approach or the purchaser/provider model towards customer-orientated service provision.

3 Framework for Public Private Service Provision

The theoretical framework for service provision from the perspective of the consumer community is based on a process of the aforementioned community being the customer and the principle of maximising the benefit for the rational consumer community [9]. In considering the community as the customer, the focus of service provision was illustrated in terms of a public private service provision based both on the purchaser/provider model and the community service model. What is essential here is the creation of the customer relationship between the service provider and the end-user of the services, the rational consumer community, that becomes possible only within the community service model.

In addition to the basic presumptions included in the theory of consumer choice, this article presumes that a rational consumer monitors the use of tax revenue collected from the consumer. Therefore he expects efficiency and a high level of quality in the provision of services that are maintained through tax revenue. This presumption is also included in the *Value for Money* principle, which has a central role in promoting the development of public service provision through public-private-partnerships. In addition, a rational consumer is expected to prefer a wider selection of services and therefore to maximise the type and number of different alternatives available and to value the opportunity to make individual choices. The consumer's ability to make individual choices and his capability to compare and choose are also included in the basic presumptions of the theory of consumer choice [10,11,12].

In this article, the assessment of public private service provision from the perspective of a group of rational consumers is founded on the following three presumptions on the basis of which a rational consumer maximises his benefits:

1. **The Value for Money principle** both in an individual's personal decisions and his behaviour as a part of the community as well as his expectation that the representative leadership of the community also adheres to the principle.
2. **Appreciation for diversity in selection** and the resultant ability to make choices between different alternatives.
3. **Independent choices** and expectation of having the possibility to make free choices based on personal preferences.

The following figure illustrates the process of assessing public private service provision, which is based on the above presumptions and which is conducted from the perspective of the rational consumer community. It also highlights the theoretical framework that can be produced from the assessment.

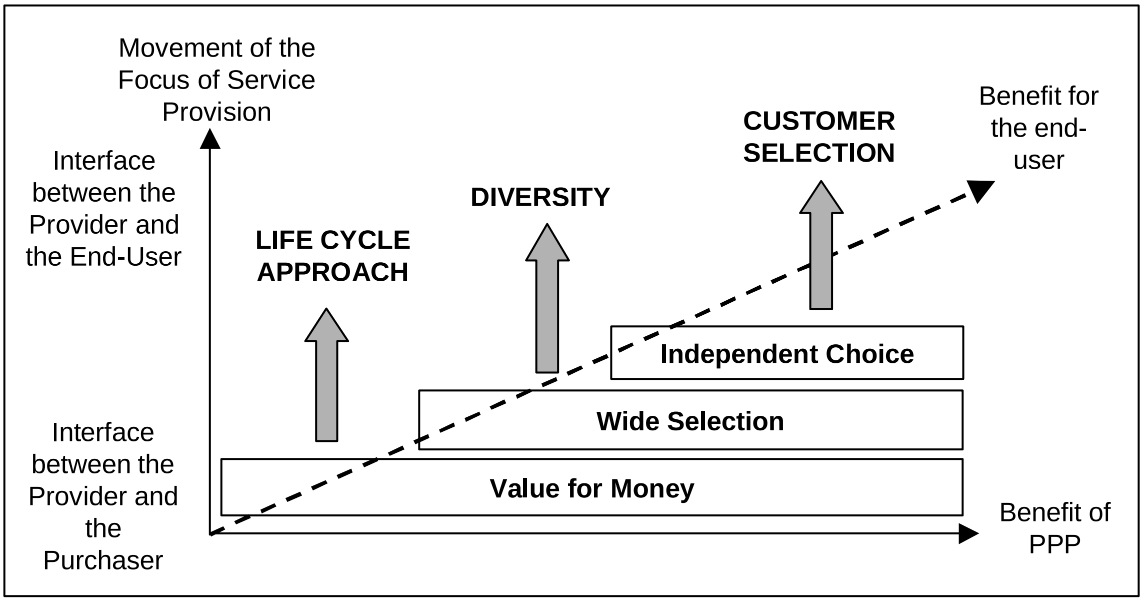

Figure 2: Benefit of public private service provision from the perspective of the rational consumer community.

The examination of public private service provision has been conducted in terms of the focus of service provision and maximisation of benefits. The vertical axis illustrates the movement of the focus of service provision from the interface between the provider and the purchaser to the interface between the provider and the rational consumer community as per the community service model. The horizontal axis illustrates the benefits of PPP in general. The dotted arrow illustrates the increase in the benefit to the end-user from public private service provision that is based on the preferences of the rational consumer community. From the perspective of the rational consumer community, the *Value for Money* principle is fulfilled through the life cycle approach. In addition, the diversity pre-requisite fulfils the wide-selection preference for the rational consumer community. Furthermore the maximisation of benefit is achieved through customer selection and, as a result, the possibility for independent choice is also fulfilled.

Examination of public private service provision from the perspective of the rational consumer community covers the structure of service provision and the scope and content of that provision. PPP, which is part of the life cycle approach, mainly concerns the investment and maintenance services that are connected to the structures of service provision and that involve its operational environment, for example. In terms of diversity, the examination focuses on the structure of service provision as well as its scope. This means an operational environment providing multiple purposes within the available resources as well as optimally diverse and versatile service provision. In terms of customer selection, the examination also involves the content of the service provision and the ability of the rational consumer to make independent choices between available forms of services. It is important to observe that from the perspective of the rational consumer community, it is irrelevant whether the service is provided by the public or the private sector or how the distribution of work is allocated between the two in relation to public private service provision. The relevant issues are the fulfilment of the life cycle approach, diversity and customer selection in public private service provision.

4 The case-study of a PPP-model for a High school and Leisure centre project

4.1 The Overview of the case

The first and only PPP-project in Finland that includes both construction and wide service supply at substance and support services is the Kaivomestari High school and Leisure centre in Espoo. The project was between BOT (build-own-transfer) and a leasing model. The private partner was responsible for the planning, construction and providing the service, exclusive of the educational element. The real estate has been funded through a leasing contract. The partners of the project company, Arandur Ltd., were NCC (the construction partner), YIT (the maintenance partner) and Sodexho (the service partner).

4.2 Evaluation criteria and evaluation process of the case

The evaluation process was based on procurement negotiations and began with a public notification on 2.6.2000 [13]. The information bulletin and pre-qualification requirements were announced in a public meeting on 15.6.2000. After the pre-qualification procedure, the call for bids for the PPP project and 25 year-concession agreement was sent in October 2000 to the three candidates (project groups lead by the construction companies YIT, Skanska and NCC). Detailed standards for technical requirements and services were articulated in the call for bids. The evaluation criteria also reflected the focus on technical and economical points [14]. The bids were then evaluated against the public comparator. The preliminary evaluation between the bids and the public comparator was conducted only from the economical perspective. As all the tendered PPP solutions were feasible against the public comparator, all three candidates were invited for negotiations in the spring of 2001. The second round of negotiations was set up only with the YIT and NCC, at which stage the candidates made their bids public. Based on the technical and economical points, the NCC group won the contract, and the school was ready to start operations in the autumn of 2003.

As this was the first PPP project of its kind, it was feasible to use a negotiating procurement procedure. In addition, all the candidates were asked to take part in a research program of possible PPP solutions in Finland which could lead this project. As was outlined in the call for bids announcement, the project also served to collect data and experience from the PPP model as an alternative to the traditional method of offering public services [15].

4.3 Case-study analyse

4.3.1 Evaluation criteria

As the article is based on a theoretical framework that reflects the end-user perspective of public services and the aim is examine the requirements of a new evaluation criterion, existing criteria should also be reviewed. This is done with a case-study, where the main criterion is the benefit to be gained with the public private service provision, as analysed from the perspective of the end user. The requirements given in the pre-qualification material and in the tendering and selection documents have been divided into three categories: Life cycle approach, Diversity and Customer selection. In each evaluation stage the given criteria are considered in greater detail.

Table 1: Evaluation of proposals from the perspective of the end-user. Criteria and weighting are based on tendering and selection documents [16,17].

CRITERIA CATEGORY	**EVALUATION STAGE**		
	Pre-qualification	**Tendering documents**	**Weighting in Selection**
Life cycle approach			
Economical factors and risk management and risk sharing	Economical requirements for tenders	Value for money principle and risk sharing mechanism from the provider's perspective	30%
Quality and technical factors related to design and construction	Technical requirements for tender	Functionality, architecture, technical usability, materials etc. from the providers perspective	40%
Quality of required services	Organisational requirements for tenders	Detailed services for the school and sport authorities from provider's perspective	10%
Project control and certainty of service performance	Organisational requirements for tenders	Detailed services during construction phase and during service –delivery time from the perspective of provider	10%
Risk sharing and economical points in concession agreement	–	Legal factors in approved concession agreement from the perspective of provider	10%
Diversity	–	Extra services identified and included in value for money principle. Economical view from the perspective of provider.	–
Customer selection	–	Private cash flow from extra services included in value for money principle. Economical view from the perspective of provider.	–

4.4 Results

4.4.1 Evaluation criteria

In the pre-qualification process the municipality of Espoo stipulated the technical and economical requirements for the tenders. At that time, the main interest was to estimate the potentiality of interested tenders on the basis of technical, economical and organisational factors. Only technical and economical requirements were made public, no evaluation criteria were given. The purpose of the pre-qualification phase was to short-list at least three, and no more than four, candidates for the ordinary tendering process.

The weighting of the evaluation criteria in selection indicated that the focus was on technical and financial points. The municipality of Espoo, as provider, tried to secure the service on behalf of its educational and sports authorities. The call for bids did not pre-exclude innovative solutions which would include some services and private cash flow. The main interest was in public services and the evaluation criteria were set up on this basis. The breakdown of the required services was specified in great detail, and the call for bids did not encourage tenders to innovate, develop extra services or to extend the service supply to end-users.

Evaluation was made from the public provider's perspective. There were no factors at all which would have necessitated a direct link between the purchaser and the end-user. All the criteria were founded on managing the interface between the purchaser and the provider. The end-users of the public services, eg., students and users of the leisure centre, were considered as a homogenous consumer group. The innovative services and diversity of the project were evaluated only on the basis of the life cycle approach and against the V*alue for money* principle.

4.4.2 Public comparator

The public sector comparative is a financial model for service delivery through the utilization of the public sector only. It provides a benchmark for evaluating the PPP alternatives [18]. In the case-study, the public comparator could not offer an all-encompassing alternative and the municipality of Espoo has difficulties in collecting the data for the comparator because all the information was not available from their own system. If the public comparator is not a noteworthy alternative, the comparison should made only for the purpose of assessing the costs of the PPP model solution against the traditional delivery of public service.

4.4.3 Evaluation group

The evaluation group was identified in the call for bids and all its eight members represented the municipality of Espoo, with representation from each of the various technical, financial, educational and legal departments [19]. The end-users had no direct representation. When the evaluation group is based only on representatives from the public sector, there is a risk that the group focuses only on the interface between purchaser and provider, and no one oversees the advantage of the end-users.

5 The evaluation of proposals from the perspective of the end-user

5.1 Framework of evaluation

Previously, the focus has been on the technical and economical values and the risk-sharing element between the purchaser and provider [20]. *Value for money* has been a primary objective in maintaining public interest and projects have been evaluated according to the cost-efficiency point of view [21,22]. These criteria have applied in PPP projects, for instance, in an evaluation method based on decision analyse, where the vital part is the regulation of evaluation: must criteria, want criteria and evaluation matrix & analysis [23,24]. As we note from the case study, the advantage of the end-user has been secondary and is evident only through the services supplied by the municipality.

When we consider that composition of the consumer group is heterogeneous, it is not important to try to make universal and unambiguous evaluation criteria for all types of PPP projects. The evaluation criteria must reflect - and be made specifically suited to - the nature of the project. It is essential that all the agreed criteria be observed from the perspective of the end-user; this can be ascertained by recognizing the advantage of the end-user as a main criterion.

Table 2: Framework of customer based evaluation criteria for PPP project and its benefits for public sector and end-user.

CRITERIA CATEGORY	BENEFITS	
	FOR PUBLIC SECTOR	FOR END USER
Criteria of Life cycle approach in substance and support services and investments and maintenances linked to them	Value for money Risk sharing and risk management	Value for money
Criteria of Diversity in substance and support services and in services directly to end-user	Increase in substance services through combining their provision or/and expanding the support services	Diversity of services
Criteria of Customer selection in substance and support service	Innovations and continuous development Confidence from security to surpass the minimum standards Value for money through private cash flow and lower yields	Possibility to make independent choices

During the first criteria, Life cycle approach, end-users expect that the PPP-model construction project or service production be evaluated as *Value for money* based in its whole life cycle. Because the end-user, through taxation, is directly or indirectly the only sponsor for public services, the *Value for money* concept is relevant for them. The *Value for money* concept has also been the primary advantage of PPP projects. The life cycle approach and *Value for money* assessment comprise two key elements [25]:

1. Monetary comparison – comparison of the cost of the proposals, expressed in term of discounted cash flows over the life of the PPP contract
2. Non-monetary comparison – comparison of all the factors that are difficult to quantify in monetary terms, but their value to government and the wider public is significant. Examples include speed of project delivery, quality of service, and security of supply.

Evaluation of bidders based only on quantitative criteria (monetary comparison) is irrelevant for large, complex projects. On the other hand, a selection process that focuses solely on qualitative (non monetary comparison) criteria may lead to subjective appreciation. It is also important that the procedure is governed by transparency of criteria. The evaluation should be based upon a combination of relevant realistic quantitative and qualitative criteria conducted through a process that is transparent and fair to all parties, including the public comparator. [26]

Diversity of services by increasing substance services through combining their provision or/and expanding the support services is the second criteria. The main idea for PPP should be how to offer more and better services for the end-user. The third criteria, customer selection, forces the purchaser to develop the concept in an open, market-based environment. From the perspective of an end-user, customer selection is the opportunity to make independent choices by selecting the desired substance service freely amongst the selection of various service providers. The end-user can make its own choice between the public, public-private and private services. This stage anticipates that there is a wide selection of service providers, and real markets can develop. In some fields where public services have been in a dominant or monopolic position, it takes time to dismantle the production structure. Free competition speeds up the innovations and depresses the price of services. Strengthening entrepreneurship and improving its conditions in these fields is closely connected to the desired development of new service structures [27]. In Finland this has been done, for example, in telecommunications and the results have been encouraging.

If the criteria in Life cycle approach category are satisfied, this can made at less cost to the public system. Diversity and customer selection can also create new innovations and services to the end-users. In an optimum case public services can become a catalyst for building new and better services to the end-users. Another noteworthy point is the possible cash flow from private use of public facilities and the rise in the utilization rate of real estate facilities. Private cash flows help to reach the financial goals of projects and to insure the quality of the service to the public provider. This also supports the first criteria by increasing the interest of investors to ask lower yields from a multipurpose property when the residual value and rental value are higher. It is also almost impossible to create a concession agreement for 25 years without gaps in service quality. If a significant part of the purchaser’s income is derived from the private sector under free competition, the facilities and service must be competitive price- and quality-wise all the time. Market-based service production needs innovations, continuous development and the confidence due to security for surpassing the established minimum standards for public service.

5.2 Public comparator

If we consider the typical tendering process in PPP projects, there are two evaluation steps. The first step occurs when the PPP-bids are evaluated against each other, and the second step is the assessment of the PPP-model bid against the public comparator. Normally this second step is conducted between the preferred PPP tender and the traditional public sector procurement at the end of the tendering process. [28]

In considering the evaluation method from the perspective of the end-user, we need to examine how the evaluation works in this new situation. When public private provision is changed from the purchaser/provider model to the community service model and the focus of the service is on the end-users instead of the relationship between provider and purchaser, we find that it is not relevant to isolate the traditional public comparator from other competitors. Traditionally the main aims of the PPPs were to explore for innovative solutions and to search for cost efficiency. From the perspective of a group of rational consumers, more aims than just the value of money are involved, such as diversity and customer selection [29]. It is not self-evident that this kind of development can only be achieved by the private sector. Public sector can also be innovative; it should strive for development and attempt to make the best proposal. From the end-users' viewpoint, it is fundamental that the public comparator be treated in a manner similar to the private comparators.

5.3 Evaluation group

In evaluation no criteria are important without the know-how on how to use them. The problem from end-users perspective is how to give 'voice' to the opinion of the consumer communities in the evaluation process. This can be done by using criteria which accommodates the consumer community, for instance, using an independent party to audit these criteria would ensure adequate representation. In its capacity as the service purchaser and decision maker, the public sector needs to give consideration to a fair representation within the evaluation group, so that it reflects the end-users as well as secures the transparency of the assessment through an open evaluation process. The process varies within projects and it depends on the public purchaser, government or municipality concerned on how consumer opinion can be taken into account. One solution is via representative democracy and another is via independent consumers or consumers groups.

6 Conclusions

This article confirms the need for an end-user perspective in the evaluation process of PPP projects. The traditional purchaser/provider service model and its attendant evaluation criteria do not acknowledge the requirements of the end-users. Concentrating only on Life cycle approach and the interface between the purchaser and provider, the case analysed indicates the lack of recognition for end-user opinion in evaluation process and criteria. In the case-study analyse, it was also noted that the main purpose of the project was to seek for a new PPP-model solution where the municipality as a provider offers a traditional service portfolio to the inhabitants of the municipality via private purchaser. The tendering process did not prepare tenders to develop innovative and customer-orientated PPP solutions.

The review of a PPP-project must be done in the interface between purchaser and consumer community where the focus is in the community service model. From the perspective of the rational consumer group, the relevant elements behind the evaluation criteria are based on life cycle approach, diversity and customer selection. Using the advantage of the end-user as a primary goal, we can create suitable framework for the evaluation criteria of PPP-projects. In criteria-setting the focus should be on questions such as how the criterion creates value for money, diversity, or makes the customer selection possible for the end user.

The used two-step evaluation process where bids are first compared among themselves and then against the public comparator is not a fair and relevant method for the end-user. In the case-study project, this was improved, as all the bids were compared to the public comparator. The problem at issue was the fact that the public comparator was not a comparable bid and the comparison was done only on an economical basis. In customer selection, the end user evaluates the service provision only on the basis of the contents of the service provision. From the perspective of the end-user, the crucial element is therefore not the service provider but rather the contents of the service concept and the relationship between its cost and quality. It is not specifically stated that the public sector cannot also assume an innovative role to develop and make the best proposal itself. If the public sector cannot offer the required service, this will become openly apparent when the public comparator in the evaluation process is given the same treatment as the private competitors.

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Designing buildings for a crime prevention strategy

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Abstract

The problem of reducing the rate of crimes in towns is therefore an emergency in a great number of countries. Criminologists debate of reducing the rate of violation in towns trough a different design of buildings and of their aggregation. This also involves a change in users' behaviour in order to reach a site control according to the theory of the "community policing".

To reach this goal a cooperation between architetcts and criminologists is strenghtly recommended. One of the trends is of reducing the rate of crime in towns through a different design of buildings and of their aggregation.

This paper aims to define how to modify traditional building components and to identify which is the level of "crime performance" to assign to different types of components and to various design solutions. A standard of "crime safety" is to be defined for each building and a scale of values is also to be defined according with the recently issued European standards "prevention of crime by urban planning and building design"

Keywords: Criminology, town design, CPTED (Crime Prevention Through Environmental Design)

1. Introduction

From the oldest times, the first purpose of urbanization is getting an higher level of living standards for the urban society. Using design to foster security has its origins in the early history of the development of communities.

Early Sumerian codes (4,000 BC.) identified the importance of respect for property rights, while the Codes of Hammurabi (2,000 BC.) introduced the responsibilities of builders to their clients. Eighth century Chinese practitioners of Feng-Shui promoted the design of harmony in space from the size of the smallest rooms to the planning of cities. Native American cliff dwellers at the same time were developing hierarchies of family and community identity and protection through the design of living space, building impregnable living areas on the face of cliffs accessible only by ladders.

European cities with historical defensive walls are a further and well known example of the historical consciousness of the problem.

Now-days, the rate of violence in towns is a relevant item of criminology in most of the industrialized countries. The problem of reducing the rate of crimes in towns is therefore an emergency in a great number of countries.

The concept of "Crime Prevention Through Environmental Design" (CPTED) has emerged world-wide as one of the most promising and currently effective approaches to reducing the opportunity for crime. Good results have been achieved in most environmental settings ranging from small stores to entire residential communities. Much is known about the relationships and causal links between street design, traffic control and behavior management. How space is designed and used directly affects profit, productivity and quality of life. CPTED concepts can be applied to an individual building as well as to an entire neighborhood.

CPTED is based on the theory that the proper design and effective use of the built environment can lead to a reduction in the fear and incidence of crime and an improvement in the quality of life.

This paper aims to define how to modify traditional building components and to identify which is the level of “crime performance” to assign to different types of components and to various design solutions. A standard of “crime safety” is to be defined for each building and a scale of values is also to be defined according with the recently issued European standards “prevention of crime by urban planning and building design”

2. Criminological tasks

One of the trends is of reducing the rate of crime in towns through a different design of buildings and of their aggregation. To reach this goal a cooperation between architetcts and criminologists is strenghtly recommended.

In the last thirty years criminologists debate of reducing the rate of violation in towns trough a different design of buildings and of their aggregation. Many criminologists believe that people who commit crimes often do so out of rational motives: that is, they want something and they consider the best/easiest way of getting it, but they will not take action unless the benefits outweigh the risks.

Under this cost/benefit model, if you make it harder or riskier for a person to commit a crime, you will reduce the amount of crime that occurs, opportunities for crime and, hopefully, crime itself.

A professional burglar, for example, will weigh the risks costs and benefits of breaking into two different houses. If one has locks and is easily visible from the street, while the other has concealing shrubbery and no defences, a widow left open, the burglar will naturally choose is likely to choose the second house. A non-professional burglar may only decide to break into a house if he or she notices an 'easy mark'. Changing the environment so that it is harder or riskier for someone to commit a crime is known as situational crime prevention. This term also includes removing the rewards for crime in order to reduce the benefit side of the cost/benefit formula.

'Situational crime prevention is directed at highly specific types of crime that involve the management, design or manipulation of the immediate environment in as systematic and permanent a way as possible so as to increase the effort and risks of crime and reduce the rewards as perceived by a wide range of offenders.'1

Some types of crime respond well to situational measures, such as graffiti, vandalism, assault, break and enter, theft, trespassing, motor vehicle theft, and computer-based fraud, etc.

Other types of crime, which are not motivated by greed but by other emotions such as hatred, fear or anger, etc., are not strongly affected by situational control's measures: domestic violence is a good example, as is serial rape, child abuse, elder abuse, and terrorism.

This program is not only a technical item, but it involves, and needs, to be effective, a change in users' behaviour in order to reach a site control according to the theory of the "community policing".

Most of people live the urban criminality emergency in an emotional way, automatically increasing the use of mechanical defence devices (such as armour-plated doors, unbreakable glasses, alarm systems etc) and accepting restrictions in their life style and in the social behaviour (less social events in the night, no use of high value wares such as jewellery, watches, nice cars etc).

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[1] Clarke, Ronald V., ed., 'Situational Crime Prevention: Successful Case Studies' sub-committee add full reference please, p. 4.

Moreover the "fear of crime" leads to prepare self defence organizations, similar to a private police organization, that may degenerate and cause acts of intolerance or violence toward people suspected as criminal groups (such as immigrants, drug addicts, prostitutes etc..), this causing further crime acts and making hardier the already difficult cohabitation of these social and ethnic groups.

In historical times everybody was conscious of his role for the care of his house and external areas; this involved not only jobs for maintenance and ornament, but also a real engagement for a strict surveillance on the areas. The result was a signal, for ill-intentioned persons, of a site well cared, guarded, thus hardly accessible.

In the last decennia the reduced level of social relations of people living in the same neighbourhood or even in the same buildings had the consequence of less of connection with the territory. The same consequence follows from the stereotyped buildings and town design and organisation.

The actual resident behaviour is to exclude from his own care the common parts of buildings and town and to refuge himself inside his private areas.

Neglected areas thus become "no-man's lands" whose maintenance and care is committed to external agencies.

Criminologist suggest to modify this type of behaviour by means of information to the residents leading to a social conscioueness: the final result aimed is to reach a site control according to the theory of the "community policing".2

Of course the better strategies involve some differences when employed for existing or new quarters. The common method is that an everyday control must be carried out by the residents who must be encouraged to find out again this important role in the social organization.

The goal is to take again under residents' care the common areas by means of reducing the extension of each of them. It is thus necessary to increase their number and to personalize them for a reduced number of users in order to increase the attachment of each of them to that particular area.

Suggested solutions are to relocate gathering areas to locations that provide natural surveillance and access control, as opposed to locations away from the view of would-be offenders. For

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2 R. M. Barboni "Perspectives of crime prevention involved by building design" IAHS world congress, Lubiana, 2001

example, all play areas should be located within the central common area of the building with as many units as possible able to glance or actively watch children at play.

Further suggestion is to place activities in locations where the natural surveillance of these activities will increase the perception of safety for legitimate users and risk for offenders. For example, well-used common areas (safe) may overlook a parking area (unsafe) to provide additional security for the parking area.

And again, placing activities in locations to overcome vulnerability of these activities with natural surveillance and access control of the safe area. For instance, common toilet facilities and laundry rooms should not be located in a remote corner of the site or at the end of a long nameless hallway. Locate these facilities (unsafe) adjacent to the entry or location where there is normally high foot traffic (safe). It is also advised to redesign or revamp existing spaces to increase the perception, or reality, of natural surveillance.

A result of this method is to create half-private areas where people can recognize each other and easily detect incoming persons. In the meantime a potential criminal should be discouraged by the possibility of being identified.

The “community policing” also involves the idea of greater transparency in buildings (Newmann 1972, Stollard 1991).; it means that staircases, entrance doors, common areas must be transparent, the purpose is to allow a person entering into a building to know in advance what and who he shall meet inside the building.

Transparency must, of course, coexist with high level antintrusion properties of building components (windows, doors, glasses, etc) and this involves a better knowledge of technical solutions and a new specialization of architects.

Outside areas, and especially the entrance area should be under visual control from the apartments; better if from living rooms and/or kitchens. Surveillance facility must be provided also for external areas such as parking areas, gardens, play grounds etc... The idea is to portion greater spaces into smaller easily controlled areas and clearly mark transitional zones that indicate movement from public to semiprivate to private space. For example, the sidewalk represents public space and the main path into a residential development is semiprivate, and a path that branches to an individual unit(s) becomes semiprivate and the interior of the unit becomes private space.

Three relevant case studies are described at Lawlink Crime Prevention Division of New South Wales Government, Australia (www.lawlink.nsw.gov.au)

Case study: Delta City

A quiet suburban community was being disrupted by high levels of malicious damage and house burglaries. Enforcement-style Police operations were unsuccessful. An analysis was performed of the pattern of crimes: they surrounded an old walkway, which joined a baseball field to a shopping centre. The walkway went between backyards and had poor natural surveillance with relatively easy access to private property

The walkway was closed, while pedestrian traffic was diverted to the streets. The problems stopped immediately.

Case study: Park Safety, Calgary, Canada

A park in Calgary was the site of a number of assaults and sexual attacks. The trees of the heavily wooded park had top-to-bottom foliage which reduced opportunities for natural surveillance from nearby streets. The trees were removed and replaced with high canopy trees with low level shrubbery. This not only significantly increased natural surveillance of the park from nearby streets, but also enhanced its attractiveness so that use of the park increased considerably. The number of assaults and sexual attacks decreased significantly. The cost of the project was kept to a minimum through service organisations and community groups working with the local authority to carry out the work

Case study: Kirkholt Housing Estate

A housing estate in the UK, Kirkholt had a very high rate of burglary (one in four dwellings in 1985). The local authority, Police and the residents of the estate co-operated in setting up a program to reduce burglary rates. Information was gathered from victims, neighbours and known burglars. The chance of a second burglary was four times as high as the first burglary (note that Australian statistics support this pattern).

Dwellings which had been broken into were given security upgrades by the town's Housing Department and some changes to utility connections were made (for example, removing coin-fed electricity systems). A watchful 'cocoon' of near neighbours was asked to keep an eye on the house – this program was highly publicised. The program went on to set up a school-based crime prevention program, groups for offenders from the area to address their problems, a cheap saving and loan scheme for the estate residents, experienced probation officers and an increase in resources to the local court.

Results: The program was intended to prevent re victimisation of burglary targets. It succeeded in this and in reducing burglary rates by 75% for the whole estate. There was no evidence of displacement

From a statistical point of view, it can be difficult to evaluate a multi-pronged strategy in that it may be difficult to isolate the effects of individual strategies on reducing crime. This is the case of CPTED programs where it is common to operate at different and integrated levels.

While individual strategies may have specific performance indicators, the group of strategies which are aimed at a particular crime problem should share a major indicator or Key Result Area – that of decreasing the incidence and/or effects of that particular crime.

Any agencies which contribute to these strategies, therefore, should agree to the overall indicator as a measure of success for their programs

3. Buildings typology related to crime prevention

In addition to a development of the site control, buildings with specialized characters are requested to increase the protection level.

The problem is to identify which parts of the building play a relevant role in crime prevention and to give to each part an evaluation of its level of efficiency, facing the proposed item.

A first step is to find out which is the type of crime that can be related to a specific building component, a second step is to classify the right solutions and the wrong solutions. This is a long work that requires an exam of all the types of components and of their way of realization and leads to large archives; an example is given in fig. 2 referred to the balconies.

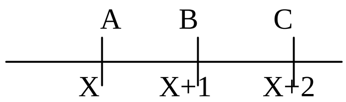
The tabulation leads to a first level of classification: the nominal scale that is based on the direct comparison of the possible solution to an assigned problem; the scale values are yes or not, this makes possible to affirm if a solution is correct or not, but does not affirm which is the value among correct (or incorrect) solutions. At this point we can say nothing between solution 4b and 2b.

A second level of classification is the ordinal scale that is based on three level comparison:3

$$\begin{array}{c} A > B \\ A = B \\ A < B \end{array} \qquad (1)$$

the (1) allows to create a sequence; so we can introduce a criterium to compare different solutions that can be better or worse than others and to find out a continuous scale where to ordinate the solutions

[3] L. Predabissi, A. Trotta, S. Soresi, "Appunti di teorie e tecniche dei test", Erip edit. Milano, 1996



(2)

and to attribute to each one a numeric value that is the measure of the difference of their efficiency. At the moment we cannot point a zero for this scale, but this is a minor problem, because we are only interested to the difference of values.

The problem is how to evaluate the efficiency of a specific solution for an assigned type of criminal attack.

	3	3	4	5
Level of potential risk ↑	2	2	3	4
	1	1	2	3
		1	2	3

Level of potential significance →

Figure B.1 – Matrix used to determine the level of protection required

Figure 1: Matrix used to determine the level of protection required.

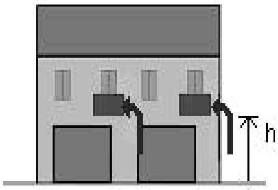
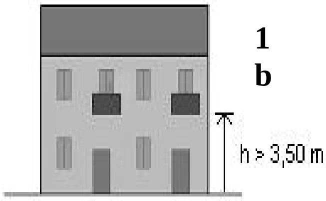
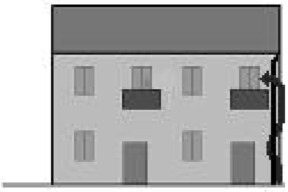
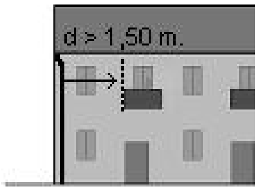
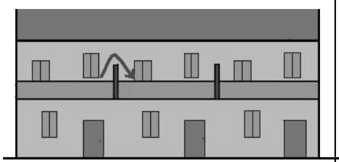
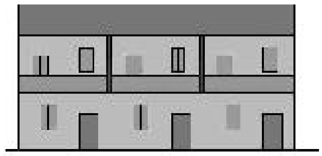
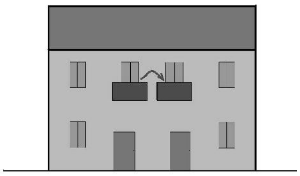
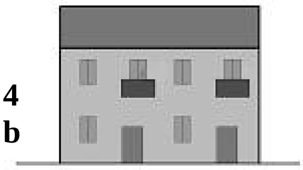
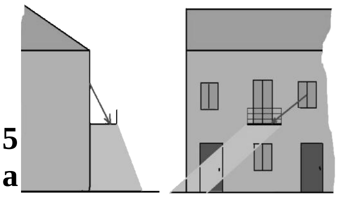
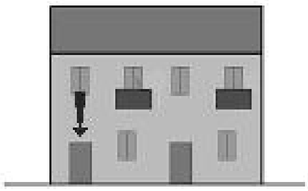
Building Component	Type of risk	*Wrong solution*	**Right solution**
BALCONY	At a lower level the criminal enters with the help of an accomplice or any support	**1 a** 	**1 b** 
	The criminal enters the balcony with the help of the waterspout	**2 a** 	**2 b** 
	The criminal enters from the gallery	**3 a** 	**3 b** 
	The criminal enters from the adiacent balcony	**4 a** 	**4 b** 
	The balcony prevents to look at the entrance door	**5 a** 	**5 b** 

Figure 2: Example of an archive of solutions referred to a building component (balconies)

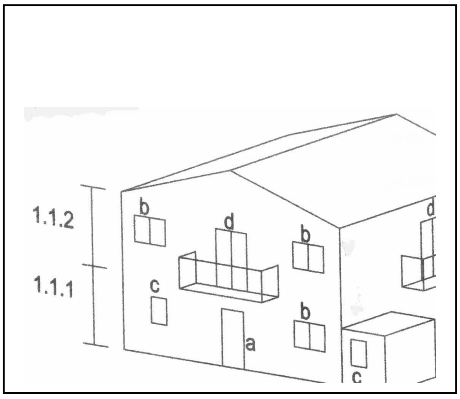
The recent european code CEN TS 14383-3 adopts the shown correlation between the risk and the protection required. The correlation is built on the basis of a model with three steps level of risk and of significance, but models with greater number of steps are allowed, and sometimes useful.

A further step of resarch is a typological analysis of buildings in order to define which component must be related to a stated level of risk. This analysis is of course depending on the type of building, its position in the town, the dimension of the town, the relation with other buildings and so on, here following an example is shown for new buildings in a middle town (80-150.000 inhabitants)

Residential housing	Group 1.1	Villas (isolated building)
	“	Serial houses
	Group 1.2	Block of flats
Commercial buildings	Group 2.1	Shops in town centre
	“	Shops in commercial centres
	Group 2.2	Larger commercial centres
	Group 2.3	Private offices
	Group 2.4	Hotels, restaurants, pubs etc.
Public buildings	Group 3.1	Hospitals
	Group 3.2	Schools
	Group 3.3	Sports centres
	Group 3.4	Theaters & cinemas
	Group 3.5	Stations, airports etc
	Group 3.6	Public & government offices

Group 1.1	1. ground floor	**a** Entrance door
		b Rooms windows
		c Bath-room & service windows
		d French windows
	Upper floors	**e** Rooms windows
		f Bath-room & service windows
		g French windows

Group 1.2	1. ground floor	**a** Entrance door
		b Rooms windows
		c Bath-room & service windows
		d French windows
	Upper floors	**e** Rooms windows
		f Bath-room & service windows
		g French windows



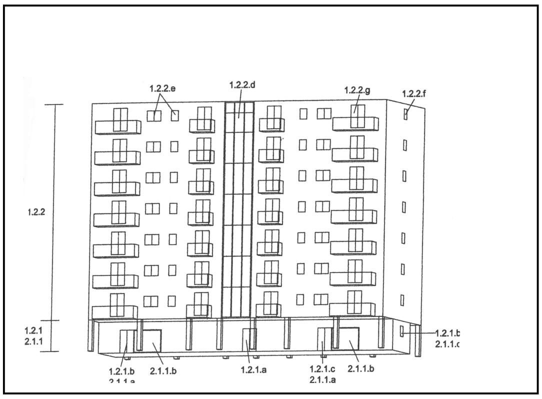


Figure 3: Typological analysis in order to assign risk and protection values to each window of a fixed building; from a research of Polytecnical University of Marche, Ancona Italy

In the example the risk level was assigned following the EU code prEN14383 which has 5 levels :

very low - low - medium - high - very high

the problem was to assign a numeric value to different components paying a role as in crime protection and to chose an algorithm that could lead to a synthetic value to be reported into the above shown risk scale

The building components that play a role come from various aspects such as the type of the area, the typology of the street, the level of the floor, and so on. As a general purpose the algorithm will be of the kind:

$$\textit{global risk level} \quad \mathbf{RL = (\Sigma\ Ri)\ \gamma\ \delta}$$

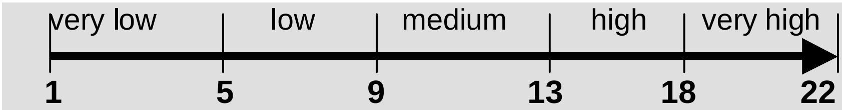
where Ri is the risk level under a specific point of view (level of floor f.i.), γ and δ are coefficients that take on count the “weight” of that point of view. The following example will make the process clear.

Tab A		
Area in the town	Suburbs	5 pt
	Semi-peripheral	3 pt
	Central	1 pt
Typology of street	One way	5 pt
	Double way secondary street	3 pt
	Double way main street	1 pt
Level of floor	Lower floor (1-2)	5 pt
	Intermediate (2 –to 6)	3 pt
	Higher (over 6)	1 pt

Figure 4 Tab A shows values of risk related to different components; tab B shows correcting coefficients related to the situation of the building.

Tab B	γ		δ
village	0,7	Well lighted area	0,5
Middle town	1	Commonly lighted	1
city	1,2	Poorly lighted area	1,3

Both tab A and B may be built up with a greater number of levels and with different values for the single items, anyway the above algorithm is valid and will show a numeric value that leads to the scale of risks provided from CEN codes. The final operation is to compare the scale of numeric values to the five steps of the CEN prEN14383; in the case of the above example this is as follows



in the case of a window at the 4th floor of a block of flats in a middle town , in a well lighted main street

$$(\Sigma \mathbf{Ri})\ \gamma\ \delta = 4{,}9$$

that means a risk level **very low**;

a window of the same building and level, but facing a one way poorly lighted street, will get

$$(\Sigma \mathbf{Ri})\ \gamma\ \delta = 10{,}8$$

that means a risk level **medium**

Once the risk level defined, the protection level required to the specific building component follows as a natural consequence (at a low risk follows low protection, at a very high risk follows a very high protection) and requirements to the component follow as well:

4. Perspectives of research

The research we are developing aims to analyse, inside a specific town, which may the correlation between crime and town design and, for an assigned building which is the level of efficiency of the building components and the adopted architectural solutions.

A first step is defining a typological organisation of the existing buildings in order to evaluate the role, and the "weight", of the typical architectural solutions.

This data organisation leads to an archive whose access is possible by building typologies (single houses, dwellings, commercial etc.) or by building components (entrances, garages, stairs

SAFETY REFERRED TO BUILDING TYPOLOGIES : **APARTMENT BUILDINGS**					
TYPE OF LAYOUT	TYPE OF FACADE	TYPE OF FLOOR	PARKING AREAS	GREEN AREAS	LIGHTING

STAIRS & LIFTS	***GARAGES***	***ESTERNAL STAIRS***	***PEDESTRIAN WAYS***
GATES	***TECHNICAL INST.***	***ENTRANCES***	**OUTSIDE FENCING**

Entrances must not create dark areas or offer the possibility to hide a criminal person.

There is a large variety of solutions in building practice: at street level, at higher level, covered by arcades, pilotis, etc.
This card shows the type and number of entrances for apartment buildings.

§ ***Linear building with single entrance***

pro: with a single entrance the criminal must cross it twice coming in and out increasing the probability of being noticed

con: with a single entrance the number of people crossing it becomes greater and the fact can induce a lower level of attention for visitors

* ***Linear building with several entrances***

pro: the increase of number of entrances helps the sense of property of each of them for the reduced number of inhabitants served thus increasing the level of surveillance

con: criminal persons have a larger choise to enter the building and of coming out from a different entrance.

FOTO A
Single entrance apartment building
Zona Palombare (AN)

FOTO B
Several entrances apartment building
Zona Grazie (AN)

INDEX	**VILLAS**	**SERIAL HOUSES**

Figure. 5 example of an archive of the expert system developed to analyse the influence of building components related to crime prevention

and lifts, balconies, arcades etc.) or by type of crime (burglary, violence etc.) and so on. A clever use of "links" (Fig 5) let us analyse the problem at the change of the selected item (type of aggregation, type of facade, type and level of lightning, type of pedestrian ways etc).

In this way we could build up an "expert system" where, by means of informatics, it is easy to find out the influence of the single variables.

This "expert system" needs, of course, the identification of the basic archives for each building component, in order of being sure to consider the whole range of possible solutions; an example of archive is shown in fig. 6 referred to windows in external walls

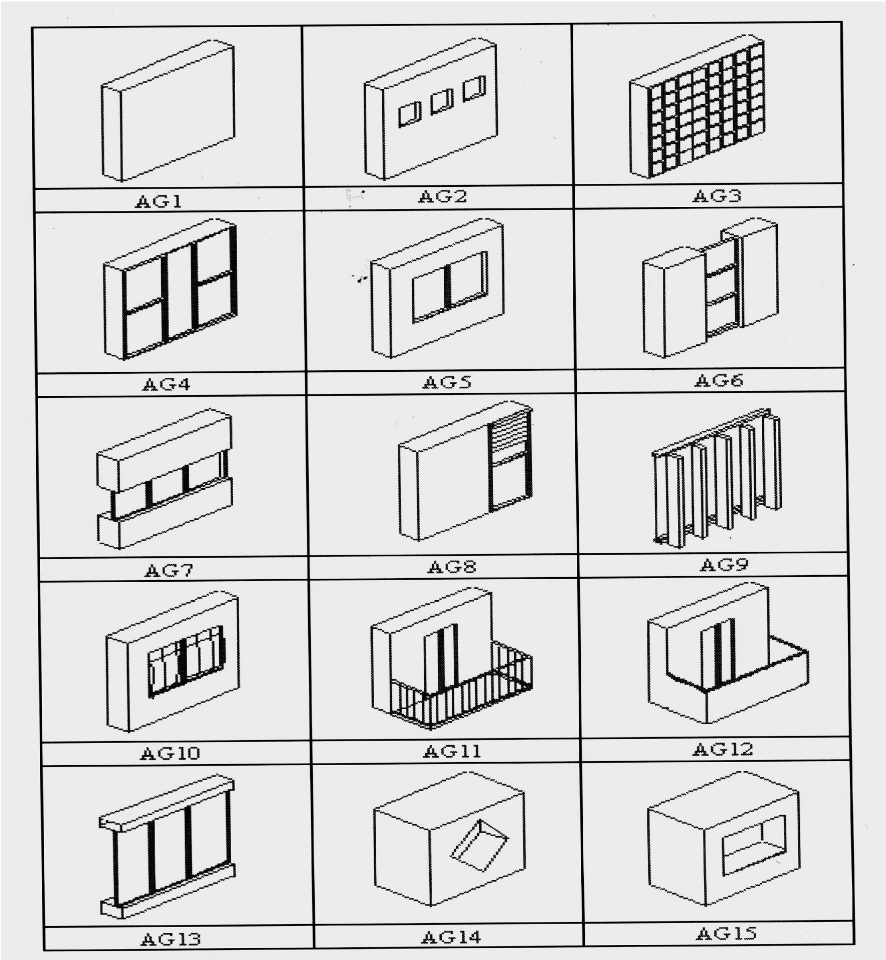


Figure 6: Shows an example of archive of typologies referred to windows in external walls, similar archives are built up for each component in order to evaluate the aptitude of the single solution to prevent crime.

5. Conclusions

It is well known to criminologists that people who commit crimes often do so on the basis of rational motives: that is, they want something and they consider the best/easiest way of getting it, but they will not take action unless the benefits outweigh the risks.

Under this cost/benefit model, if you make it harder or riskier for a person to commit a crime, you will reduce the amount of crime that occurs, opportunities for crime and, hopefully, crime itself.

A professional burglar, for example, will weigh the risks costs and benefits of breaking into two different houses. If one has locks and is easily visible from the street, while the other has concealing shrubbery and no defences, a widow left open, the burglar will naturally choose is likely to choose the second house..

Changing the environment so that it is harder or riskier for someone to commit a crime is known as situational crime prevention. This term also includes removing the rewards for crime in order to reduce the benefit side of the cost/benefit formula.

Not all types of crime are sensitive to situational measures (fraud, for instance, isn't), but the most common crimes such as vandalism, assault, break and enter, theft, trespassing, graffiti , etc. are sensitive.

The research shows how architectural design has a relevant role in situational crime prevention and that a correct design may outcome an effective crime prevention device in town design.

The basic idea of increasing residents' watch as a crime prevention method, can be realised in a plenty of different ways depending both on the ability of the architetcts, and on the level of risk for the area, but as a first step a perfect knowledge of the correlations between building components and of their weight in crime prevention is of basic importance.

The following step is assigning to each component (or architectural solution) a numeric value related to its efficiency in preventing crimes (or a specific crime). The said value can be modified (increased) in two different ways: by changing the design, or by adopting an higher level of protection for relevant parts of the component.

For instance, the use of breaking-safe glasses instead of common thermal glasses can improve housebreaking resistance without modifying the aesthetics of the building; the same level of improvement can be obtained by means of the use of metallic gratings or railings, but with a change in the exterior aspect of the building. To the architect, or to the owner, the choose, but finally based on a well know (numerically identified) level of efficiency.

Of course improvement in crime prevention is based on strict cooperation among architects, criminologists, and public institutions, but also on the evolution of the cultural an social background of residents, and, last but not least, on the budget.

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Perceptions of Personal Safety in relation to the Physical Environment of University Campuses

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Abstract

This paper discusses research at the University of Glamorgan which focuses upon personal safety on the university campus, its immediate environments and access routes. The issue of personal safety is significant because of the design and layout of many university campuses and facilities. Campuses are often large open spaces and lack systematic access control, which may lead to a higher propensity for campus users to experience victimisation and fear. In addition, previous research has shown that university students are more at risk of being victimised than the general population. The primary objectives of the research were to identify areas of the campus that posed possible threat and vulnerability to campus users and to identify solutions in the form of design and management modifications that were based on users' perceptions of their personal safety. This user-led approach produced a number of cost-effective and achievable recommendations for modifications so that all users could feel safer, as well as a generic, evidence-based model for comparable universities to emulate. The initial research determined the most common routes around campus used by three discrete user groups: staff, students and visitors. From this analysis representative routes were selected for each user group. A digital camera was used to take a number of 360° panoramas at key points along the routes which were then 'knitted together' using QuickTime software to produce a 2-dimensional virtual representation of the routes. These 'virtual reality' walk-through scenes of the routes were presented to focus groups where perceptions of personal safety were discussed. Possible solutions to personal safety concerns were considered in the form of the design and maintenance of existing facilities. Key findings from the preliminary research have identified a hierarchy of concerns and some practical recommendations that would improve campus safety. These were concerned with improving visibility, the issue of empty spaces and the need for more effective security measures. The methodology forms a cost-effective, versatile and insightful research tool that can be used to explore personal safety concerns in relation to the facilities of any organisation or environment.

Keywords: personal safety, university campuses, perceptions, virtual-reality.

1. Assessing personal safety on campuses

1.1 Introduction

This research focuses on a comprehensive exploration of how campus users perceive their personal safety on and around university campuses with particular emphasis on the physical characteristics of the campus environment. The salience of this research topic has been highlighted by a recent UK Government Home Office study that showed that a third of university students suffered some form of victimisation in the previous year [1]. Students are particularly likely to experience crime and personal safety incidents because they are young and vulnerable and because of the propensity of campuses to have specific crime and personal safety concerns linked to their design and physical layout. Sloan et al [2] observed that “campuses are typically park-like and easily accessible day and night. This openness may create high levels of fear and perceived risk of victimization among members of the campus community.” Universities can also have difficulty reconciling their traditional ‘open access’ philosophy with a safe environment and this inevitably has incidental consequences for the personal safety of campus users.

The University of Glamorgan was used as a case study for the research, and a comparative study will be undertaken at Loughborough University. The methodology used to elicit users’ perceptions on the two campuses was based on the ‘Virtual Reality (VR) Panorama Tool’. Quick Time software was used to develop a two-dimensional virtual representation of routes across campus which were presented to participants in focus groups. This perceptual approach offered profound insights into how the physical environment of the university correlated with feelings of personal safety. This instrument has been successfully used by the SLTRI in a study for a local train operating company, Valley Lines, which explored how station environments were perceived in terms of personal safety. The study by Cozens et al [3] led to a range of modifications to the design of the station environments, including transparent shelters and removal of overgrown vegetation.

The campus study has so far led to the identification of a range of cost-effective, practical and user-led solutions to promote the personal safety of campus users. Initial findings from the research are encouraging and point to the overall portrait of a relatively safe campus during the day. However, the physical environment was decoded differently at night and this had a significant impact on concerns over personal safety. Issues that users identified as influencing their personal safety included lighting levels, landscape, security equipment, the campus perimeter and the institutional open access philosophy.

2. Campus safety and the physical environment

2.1 Previous research

US research into campus crime and student victimisation spans four decades and several studies have explored the prevalence and nature of victimisation risk to students, focusing considerably on their demographic profile and characteristics of the campus environment as possible causes of increased risk. Much of this research is grounded in criminological theory, which centres on attempts to deconstruct why crime occurs and to suggest possible ways as to reduce or prevent crime from occurring. In the UK, such campus research is limited although there has recently been recognition of the salience of the topic [1, 4, 5]. Having established the particular risks to students, the UK Governmental studies have clearly triggered interest in this area. However, it remains that responses to issues of concern on UK campuses are usually reactive rather than proactive.

One of the most convincing criminological theories for explaining campus crime and risk of victimisation is the routine activities theoretical framework. This contends that three critical factors have a decisive effect on the likelihood of a crime taking place: a "motivated offender, a suitable target or victim and the absence of a capable guardian," as devised by Cohen and Felson [6]. It is suggested [7, 8] that on university campuses these critical elements are particularly significant owing to students' characteristics and the nature of the campus environment. The 'problem analysis triangle' is a useful crime reduction framework derived from this [9]. This maintains that any crime requires a victim, an offender and a location and that a crime can be averted by eliminating or adapting one of these key elements. This thesis highlights the crucial importance of location or environment in determining the probability of a crime occurring and it is this latter element that underpins this paper.

Research shows that fear of crime on university campuses can be influenced by different features of the physical environment. Nasar et al [10] argued that students felt less safe in areas with a high number of trees and dense vegetation, which provided locations for potential offenders to conceal themselves, while Robinson and Mullen [11] maintained that areas such as car parks and alleyways, specifically those which were secluded and had little 'human traffic', fostered fear. This stance is given greater credence by extensive supporting research from the criminological literature that correlates crime with the design of the physical environment. This is encapsulated neatly by Nasar et al [10] who suggest that reducing levels of fear on campus may be achieved through changes to the physical environment. An example of campus research that concentrated on ways of redesigning the physical environment was a study by Rengert et al [12]. Using high definition Geographic Information Systems (GIS) they located 'hot-spots' of victimisation on campus by analysing campus crime data and introduced appropriate situational crime prevention measures to improve safety. 'Situational crime prevention' (SCP) is a crime prevention approach that addresses specific ways of altering the physical environment to reduce the likelihood of crime. Examples include improved street lighting, increased natural surveillance by establishing, for example, Neighbourhood Watch groups and modified building design. The main criticism levied at situational crime prevention measures is that they can result in the displacement of crime from one area to another. However, there is also a considerable literature that supports the effectiveness of this approach, such as the work cited by Clarke [13].

2.2 Critique of previous campus research

The main criticism levied at the previous research into campus crime and student victimisation is that most of it uses recorded crime statistics and are underpinned by typically quantitative methodologies. This raises important questions about the accuracy of such data in reflecting reality and their validity in being the basis for underpinning crime prevention strategies and personal safety responses. Understanding crime by using recorded crime data is questionable because it has been found to systematically underestimate real levels of crime. Maguire [14] encapsulates the concern for the 'dark figure' of crime, which refers to unreported and unrecorded crime. Using official statistics as indicators of crime risk give limited indications of the social and situational context of the criminal offences, or the propensity for certain people to be more vulnerable than others [14]. It is therefore arguable whether objective approaches provide a fully representative portrait of victimisation, its causes and effects and accurate insights into possible focal points for campus improvements. For example, Rengert et al [12] sought students' perceptions of safety using quantifiable attitude responses which arguably provided an inadequate and superficial understanding of safety concerns.

In response to these concerns, this research sought to adopt a more rigorous and focused exploration of campus safety. In order to conduct more meaningful research a multi-method approach was adopted that encompassed both a perceptual approach and a statistical approach. Perceptions are arguably a more realistic portrayal of users' concerns than statistical approaches allow for and can lead to environmental improvements that more accurately reflect the needs of end-users. The importance of perceptions has been highlighted in relation to studies of crime and safety by Skogan and Maxfield [15], who found that users' perceptions are a more accurate indicator of safety concerns than simply using objective crime data. Pain [16], meanwhile, suggests that "qualitative and humanistic methods offer the most enlightening prospects of investigating the interactions between identity, social relations and place". This research sought to translate both forms of data into tangible improvements that objective indicators of risk on their own could not accurately record.

3. Defining personal safety

Having established that personal safety on University campuses is a pertinent research area, a thorough exploration of the literature was undertaken in order to gain an understanding of the concept. However, despite 'personal safety' being a term that is frequently and intuitively used in daily life, it is a widely misinterpreted term and lacks clarity. This was confirmed in a review of the literature, which revealed that no studies explicitly defined the term ‘personal safety’. Although Maurice et al [17] defined the more generic term ‘safety’, and Schroeder & Anderson, [18] Bilsky et al, [19] Burckhardt & Anderson [20] specifically used the term ‘personal safety’ in their research, none of these studies provided a lucid definition of the term ‘personal safety’. A review of the criminological literature, however, established a clear link between personal safety and crime. The notion of safety is firmly embedded in the criminology literature and there is a proliferation of the word ‘safety’, sometimes ‘personal safety’ and often ‘security’. Cozens et al [3], Lund & Hovden [21] and Barker and Page [22] all refer to personal safety as the focus of their research yet none defines what this elusive term means. Significantly, however, Austin et al [23] found in their study of neighbourhood conditions on perceptions of safety that “although fear of crime and perceptions of safety were separate concepts, they had significant theoretical and empirical commonalities”, which serves to acknowledge and document the relationship between crime and personal safety and suggests that some established theories of crime may be applicable to personal safety.

In response to the lack of definition, and prior to a campus assessment being conducted, it was necessary to produce a robust and academically useful definition of the term ‘personal safety’, as reported by Waters et al [24]. The Delphi Method was selected as the appropriate technique to attain a definition. The resulting definition of personal safety can be crystallised as relating to *intentionally motivated harm against the individual, their property or their personal effects.* Personal safety was found to be a complex composite of three causal converging determinants - physical, social and personal factors - which interact as an individual’s environment changes; personal safety is thus a transient phenomena. This framework provided further support for the commonalities between personal safety and crime; Pain [16] highlighted the tripartite relationship between individuality, social relations and the physical environment to explain what can cause fear of crime. There are thus clear parallels to be made between personal safety and the fear and risk of harm and the fear and risk of crime. Critically, this study established that personal safety is not a single dimension issue; *perceptions* of personal safety, in addition to *actual* personal safety, were both found to be crucial components of an individual’s personal safety. It was therefore imperative that the methodology for the campus research was designed so as to focus considerably on subjective perceptions because of their ability to reveal how people construct their personal safety in line with changes in the social and physical environment.

4. Methodology for the campus study

The University of Glamorgan was used as a case study for this research, with a smaller scale comparative study being undertaken at Loughborough University. The rigorous multi-method approach consists of three key components. **Questionnaires** asked for respondents overall perceptions of security on campus, whether, where and when they fear for their safety on campus and whether they have been harmed on campus. They were also asked to identify their three most common pedestrian routes across campus on a map. Analysis of these routes determined which routes would be filmed for presentation to the focus group. The **VR Panorama Tool** was used to film representative routes identified from the questionnaires. A digital camera was used to take

16 digital still images at key points (nodes) along the route. These 16 images were ‘knitted together’ using QuickTime software to produce a fluid 360° panorama, which were then ‘knitted’ to the other nodal panoramas, resulting in a 2-dimensional virtual representation of the route. This standardisation of the route ensured that participants responded and reacted to a consistent stimulus. These ‘virtual reality’ walk-through scenes of the routes were used as the stimuli in **focus groups** where perceptions of personal safety were explored. The technology allows for participants to move backwards and forwards through a route as requested, proving a more accurate representation of reality than static photographs. This approach explored how personal safety is influenced by the physical conditions on campus and identified any ‘trouble spots’ that exist. The study has so far consisted of a pilot focus group consisting of 12 undergraduate students, which explored a day-time and night-time route on and near campus and the analysis of 46 questionnaires (out of 120 distributed) with the following breakdown from each user group: 21 staff; 17 students; 8 visitors.

5. Key findings

Analysis of the questionnaire and focus group data led to the identification of key characteristics of the campus environment that influenced users’ perceptions of personal safety along with some possible situational solutions to improve personal safety on campus.

Table 1: Those campus features that invoked concern for personal safety and some suggested solutions for improving personal safety

Risk factor:	Risk caused by:	Possible safety solution:	Risk potentially reduced by:
Low lighting levels and state of darkness	Reduced visibility and reduction in social presence	More street lighting	Street lighting improves visibility and boosts confidence
Landscape concerns such as tall and dense vegetation	Opportunities for potential offenders to conceal themselves	Less dense vegetation	Providing more visibility and reducing opportunities for offenders to come on campus unnoticed
Insufficient security equipment	Lack of help response if victimised	More CCTV	Reassurance that individuals and their property are being protected and, if an individual is victimised, it will be noticed and help will arrive.
Problem of leaving campus and entering local community	Less protection when in local community	Improved lighting Security guards patrolling key routes off campus	Better visibility Security guards provide social reassurance
Open-access ethos of universities	Unable to monitor who comes on campus and enters buildings	ID cards, electronic swipe cards	More control over who uses the campus and easier to identify individuals who aren't on campus for valid reasons

6. Discussion

This discussion involves an exploration and critical evaluation of the five main risk factors relating to the physical characteristics of the campus and the effectiveness of possible situational solutions in reducing fear and increasing personal safety on campus.

Lighting levels

Personal safety concerns were considerably lower during the day, due mainly to high levels of visibility and high numbers of people to provide social reassurance. However, such perceptions changed dramatically at night as light conditions (and subsequent social conditions) changed. The state of 'darkness', it seemed, and what this signified in terms of reduced visibility and a corresponding reduction in the number of people in the vicinity as standard university hours ended, fundamentally changed the dynamics between people and their environment. The campus users generally thought the daytime route would be a lot less safe at night and the lack of illumination (natural and artificial) dramatically increased perceived risk. Some comments from the focus group included:

Participant 11: "Feel less safe at night – darker."

Participant 7: "Lighting is a big issue with making you feel safe."

In the main study questionnaires, 47% of all campus users thought that there was adequate lighting on campus. However, improved lighting was often cited in the questionnaires and focus groups as one possible way of improving personal safety on campus during the *state* of darkness. It would seem that such a security measure works by boosting self-assurance and personal safety levels by improving intervisibility of the immediate vicinity. However, it is generally accepted that improved street lighting only partially improves personal safety. This is supported in the criminological literature by Nair et al [25] who found that improved street lighting can considerably reduce fears and improve *perceived* safety, while Atkins et al [26] concluded that while this is true, the introduction of improved street lighting does not reduce actual risk (in terms of reported crime). Thus such measures to promote personal safety should ideally be implemented as part of a package of solutions.

Landscape

The other principal factor influencing personal safety was the physical environment – natural and built - of the campus. In particular, enclosed, quiet and remote spaces on campus, such as stairs enclosed by dense vegetation, the car park and the smoking shelters, which could present as hiding places for potential offenders, figured highly in respondents' fears and concerns for their personal safety. One location mentioned frequently in the questionnaires as being an unsafe place was the tunnel end of the main car park, which was decoded as being poorly lit at night, surrounded by high vegetation and enclosed on three sides. Some remarks from the focus group included:

Participant 1 "Car park is dark, bushes all around."

Participant 12 "No-one can see anything that goes on so if you are accosted or something bad happens at that point no one can see you because of the trees."

Analysis of the night-time route data showed that the physical environment was perceived to impact on senses of personal safety. A key entrance gate onto campus was perceived as dark and threatening as were back lanes adjacent to the entrance; most students in the focus group would avoid walking down these lanes at night and sometimes even during the day. These insights about the impact of the design and layout of the physical environment are echoed by Fisher and Nasar [27], who discussed how certain physical characteristics of the university campus environment, such as 'blind-spots' and places of concealment, can increase vulnerability and feelings of fear.

Security equipment

The lack of physical security equipment was a concern cited in the questionnaires and in the focus group. There was a degree of cynicism aimed at the current use of CCTV on campus, with some respondents intimating that it is useful only when it is being constantly monitored. However, 24% of users thought there was inadequate CCTV and many focus group participants cited CCTV as one possible solution to personal safety concerns on campus. The lack of security such as CCTV and lighting on the night time route, particularly off campus en route to the local train station, was a primary concern.

> *Participant 1 claimed her personal safety would be improved: "If you had CCTV there knowing that someone's sitting in an office watching the screens."*

CCTV can be effective in increasing perceptions of personal safety because it acts as a deterrent to potential offenders and it provides reassurance that such surveillance, if used appropriately, can immediately alert security personnel if threatening situations arise. This is supported by research carried out by Ditton et al [28], who found that 79% of people questioned thought that they would be less likely to become victims of crime in areas with street cameras. However, Campbell and Bryceland [4] proclaim that "CCTV alone will not reduce crime but …. if properly managed and monitored it will have a lasting effect on crime reduction and community safety." The findings suggest that inadequate lighting and CCTV both play a key role in making campus users feel less safe on the campus and contribute to the sense of a more sinister night-time environment.

Campus boundary

Routes within the campus boundary provided an almost intrinsic safety, a sense that users were better protected on university facilities than in the surrounding local environment. This was particularly an issue as users left the campus via a key entrance gate and entered the local neighbourhood. When participants left the perceived safety of the campus environment they claimed that they experienced different perceptions of personal safety as they entered the local community.

> *Participant 10 claimed that: "If you leave the campus it's a different thing all together – you are outside there and parts of that were very dimly lit and hardly any people. I wouldn't be happy or have a safe feeling at all."*

This relates in part to the issue of control. As Donnelly [29] observed, a common factor that plays a role in influencing fear of crime is the sense of control. Experiencing feelings of loss of control, for example over one's environment, can result in heightened fears and concerns. It could therefore be suggested that users feel they have more control over their environment on the university campus, thereby prompting an increased sense of personal safety on campus. A possible solution is to have security guards patrolling the key routes off campus.

Institutional open access philosophy

While the open access policy of the university can be equated to the lack of literal physical restrictions that prevent people from accessing an environment, it is the consequent impact that this has on the social presence that is perhaps most significant. The result of this is that 'anyone' can come on and off campus unchecked, regardless of whether they are there for reasons connected to university business or not. This was a concern particularly at night, when there were less people available to provide natural surveillance.

> *Participant 1 claimed that: "Anyone can get on and off the campus easily enough regardless of who you are and I wouldn't feel any safer walking around here than around Pontypridd (the local town), I don't suppose."*

However, this is a complex issue since the very ethos of an open access educational environment underpins the whole principle of a welcoming, accessible and creative learning environment which would be dramatically altered if a fortress image was adopted. However, perhaps some compromises have to be sought to try to reconcile the historical and philosophical rights of universities to retain some semblance of an open access ethos with the need to provide effective security on campus that maximises personal safety. Campbell and Bryceland [4] suggest that "the foundation on which to build a safe and secure environment is a tried and tested access control policy." The introduction of ID cards, perhaps initially limited only to certain areas of the campus, is one possible method of monitoring the rightful use of campus facilities without suppressing accessibility for valid campus users.

7. Conclusions

The study has supplied some intriguing preliminary findings that give an interesting indication of perceptions of personal safety on the University of Glamorgan campus and indicated what physical attributes of the campus need to be explored to promote personal safety for users. This provided opportunities for developing solutions that are grounded in users' every-day beliefs, actions and perceptions. The findings encouragingly suggest that the campus is a safe place during the day and there is probably only a limited number of actions that can be taken to improve it during daylight hours. Naturally occurring conditions as a direct result of the university environment such as institutional responsibility, high social presence and, of course, daylight, denote that personal safety is almost inherent to the university during the day. However, perceptions of safety noticeably decrease at night, and this is exacerbated by certain features of the physical environment. Recommendations for possible situational solutions to improve personal safety and reduce the risk of victimisation were therefore mainly in terms of tackling the negative effects of darkness and included upgraded lighting and CCTV, which would provide reassurance to some extent by improving visibility and reducing users' fears. The caveat is that although such measures are often cited as reducing fear, their actual effectiveness in terms of reducing victimisation is uncertain and should therefore form part of a package of solutions rather than stand-alone solutions. Another useful intervention would be to have an increased security presence patrolling the campus, *and* the immediate local environs, to strengthen the image and relationship of security staff with university users and to clarify security guards' roles on campus. Such situational crime prevention measures implemented to improve personal safety should not be viewed as a panacea to all personal safety concerns; rather, they should be integrated into a comprehensive package of solutions that together maximise personal safety on campus.

Beyond its utility in assessing and improving personal safety on university campuses, the methodology developed has considerable industrial relevance. It forms a versatile, insightful and transferable research tool that can be used to explore users' perceptions of personal safety in relation to the environmental facilities of any organisation or environment, including transport nodes, hospitals, schools, recreational services, hotels, banks and retail establishments. The methodology also translates into a sustainable applied research capability that is cost-effective and based on the premise that user groups can be effectively used in decision-making processes. It can also be used to explore issues such as aesthetic preferences and the architectural and design requirements of different user groups. For example, it can be used to explore the relatively unexplored issue of how the disadvantaged and minority groups perceive their environments and their specific needs and how this in turn affects how they use facilities and environmental spaces.

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Developing a New Framework for Infrastructure Asset Management

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Abstract

Maintaining the infrastructure asset is an important issue. In Japan, there is a large amount of the infrastructure stock constructed during its modernization era and they are getting older year by year. The local authorities who manage the most portion of the infrastructures do not have technical and financial background enough to perform periodic inspection and preventive maintenance of their infrastructure asset. They do not well maintain their infrastructure and are facing the crisis of losing the function of their asset. However, the existing technologies such as bridge management systems require detailed inspection data and high operation cost. So we propose a new framework of asset management which enables the authorities to conduct the asset management with limited technology and financial background. This framework allows the authorities to undertake the asset management and to realize the sustainable infrastructure services.

Keywords: Infrastructure, maintenance, management system, asset management

1. Introduction

Japan has a large amount of infrastructure stock constructed during its modernization era in 20th century. The considerable amount of structures such as bridges and tunnels were formed during 1960s and 1970s so they are getting older year by year. The most portion of the infrastructure is managed by local governments. For example, Japan has a 1,177,000km road network and the 98 percent in length is managed by prefectural and municipal governments. The budgets of them are not enough for the expenditure required for the maintenance and they are facing the shortage of the budget for the maintenance of their asset. It means that they do not well maintain their asset. Furthermore, we cannot expect that in future, the efforts to secure funding for the repair or maintenance of the road structures will be easily provided.

Table 1: Road network system and the expenditures for road maintenance in Japan

Road Type	Length (km)		Expenditures for Maintenance	Expenditure per km
National Highways (Class-A)	6,851	0.6 %	703,267	32.2
National Highways (Class-B)	21,828	1.9 %	178,153	5.6
Prefectural Roads (Regional)	32,028	2.7 %	256,564	4.5
Prefectural Roads (General)	128,409	10.9 %	213,491	3.0
Municipal Roads	982,521	83.9 %	583,297	0.6
Total	1,171,647	100 %	1,934,772	1.7

Unit: JPY Million
Source: Road Statistics Annual Report (Japan)

2. Issues of Asset Management in Japan

2.1 Overview

The stringent financial situations in recent years have forced the authorities to limit the budget for infrastructure, and it has been becoming increasingly difficult to allocate the funds as desired. In other words, as budgets has become to be allocated for specific, higher priority expenditures, it has become increasingly difficult to allocate enough funds for maintenance. Such a situation is severer especially in the local governments. According to the survey held by Japan Society of Civil Engineers (JSCE) on Japanese local governments, the issues of their asset management are summarized as follows.

(1) Issues of Asset Strategy
Only a few local governments have asset strategy. So most of them cannot create the alternatives based on life cycle cost nor environmental effects.

(2) Technical Issues
Only a few local governments perform periodic inspection of their structures and facilities. So most of them do not collect the data of the condition of their facilities including inspection results. They do not have technology for deterioration prediction and maintenance planning.

(3) Financial Issues
In Japan, the funds have been concentrated on new construction, replacement and improvement because the importance of maintenance has not been well understood. The financing system such as subsidies and bonds guaranteed by central government targeted on capital investments may distort the optimal choice of alternatives.

So the infrastructure management authorities in particular local governments need the methods and tools to establish and conduct their asset management and to realize the accountability to citizens, local assemblies and financial authorities.

2.2 Technical Issues on Asset Management

Now there are established methods for routine, standardized inspections and tools to provide the understanding of the condition of the structures and the facilities. There are also the systems for network-level management which assist maintenance and repair planning. For example, the United States has PONTIS system used by highway management authorities inside and outside the US. Japan is now developing management systems proposed by the Ministry of Land, Infrastructure and Transport (MLIT), Public Works Research Institute (PWRI), Hokkaido Civil Engineering Research Institute (CERI) and so on. However most of them are not applicable to authorities like Japanese local governments because the systems require periodical inspection data in detail and considerable operation cost. Therefore the local governments cannot undertake their asset management with the existing management tools. It is required to solve the issues to establish the asset management responding to the era of maintenance.

3. A New Framework for Infrastructure Management

3.1 Objectives

As the solution to the issues of the infrastructure management in Japan, the authorities need the methods and tools of asset management which can be applied under the condition with limited data and low operation allowance. So we propose a new framework of asset management which is applicable to authorities like Japanese local governments considering the following requirements.

The requirement for the framework are as follows:

-The management framework can be applied under situations with limited data which are inadequate for existing management systems.

-The management framework can be easily understood by executives who do not have engineering background and are not familiar with the sites of infrastructure such as citizens, local assemblies and financial authorities.

-The management framework can utilize the existing asset management technologies for maximum regarding strict financial condition.

Therefore, we reviewed the decision making process of the authorities in the management and maintenance, then designed the framework because the existing systems do not necessarily agree with the decision making process.

3.2 Concept

We can state that there are essentially two aspects in the asset management of the infrastructure. One aspect includes the inspections of individual structures, and the repair and maintenance activities. The other aspect is to formulate plans and allocate budgets for maintaining them in the most desirable way considering the overall infrastructure such as road networks and structure groups.

The former is conducted by the local field offices responsible for the operation and maintenance of structures and facilities at site and the latter is conducted by the headquarters responsible for the infrastructure as a whole. In terms of budgets and funding, the most important aspect of the former is securing the funds needed to maintain their structures and facilities in good condition. The responsibility of the latter is determining the optimal allocation of funds regarding the entire asset inventory under the charge of the authorities considering other policies such as capital investments etc.

Different information is required for each aspect of management. While the former requires detailed information of individual structures (degree of deterioration of the structures and their parts and members), the latter needs to know whether the structural conditions are improving or deteriorating as a whole, or whether there is any imbalance between districts or routes. It is not reasonable to consider the degree of deterioration of each structure for the purposes of determining nationwide budget allocation.

Therefore we propose the framework of asset management should include individual facility management and network (or a group) level management as shown in Figure 1.

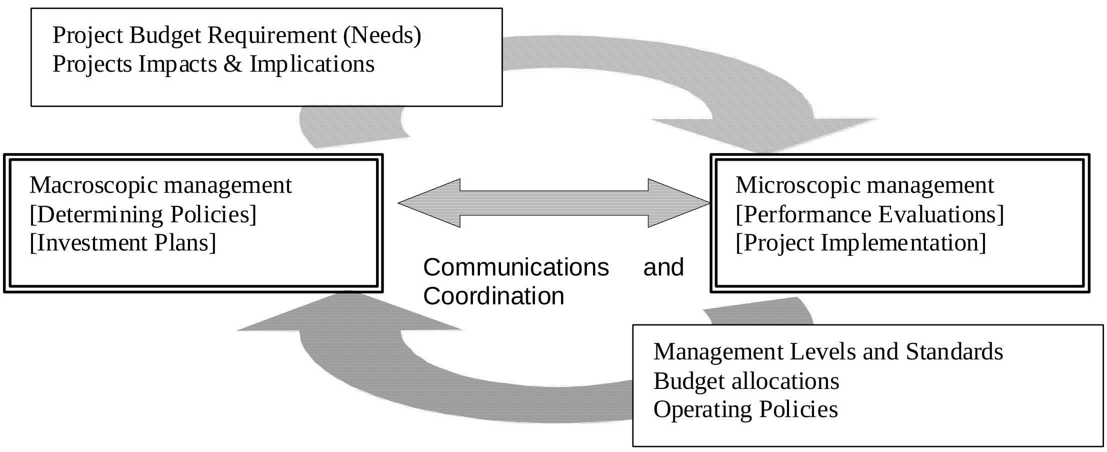


Figure 1: Structure of the new framework of the infrastructure asset management

The concept of the framework is as follows.

- -The management framework is composed of two components, individual facility management and network (or group) level management. We name them the microscopic management and the macroscopic management.
- -Both management components intend to the optimal management within their own scopes. The former is primarily responsible for operation and maintenance of individual structures at site. The latter is responsible for the management of the overall asset inventory, including total management planning and budget allocation.
- -Both management components communicate, cooperate and exchange information interactively, so they form the management cycle to realize the asset management in the most effective way.

3.2.1 Microscopic Management

The objectives of the microscopic management are providing appropriate maintenance and management to each individual structure, for proper structural functions in the face of deterioration and damage due to aging.

The microscopic management process is conducted with two types of indicators, indicator of the health and safety of each individual structure (Health Index) and indicator of the level of deterioration or damage of the parts and members (Damage Degree) of the structure applying deterioration scenarios.

(1) Health Index

The health index indicator reflects the safety of individual structures. It generally refers to how weakened structural functions may have become due to deterioration by aging or other factors. The indicator is expressed either as a percentage against a perfect score of 100 where no deterioration is noted, or five-levels definition.

The structures are composed of parts and members. Therefore, it is assumed that accumulated damage (damage degree) for each parts and members impacts the overall health index of the structure as a whole. With this assumption, for the more damage to parts and members, the lower the health index will be indicated. The health index is calculated with the following formula.

$$\text{Health Index} = (AX+BY+CZ+\ldots) / (A+B+C+\ldots)$$

Here, X, Y, Z…:numerical value of damage degree of each part or member as 'the lower degree of damage gives the higher numerical value'.

A, B, C… :weight coefficient of each parts and members

(2) Damage Degree

The damage degree is a quantitative indicator defined for each type of damage affecting parts and members of the structures. According to the severity and extent, the damage degree can be expressed in levels as shown in Table 3. The damage degree is used to ascertain the conditions of deterioration of the parts and members, and consequently, for the selection of repair works. The damage degree is also used for calculation of the health index shown above.

The damage degree as shown here is similar to the definition in the guidelines now in use for bridge inspections in MLIT but other measurement rules can be used in accordance with the inspection and deterioration evaluation standard of the authorities.

Table 3: Damage degree of individual structures (example for road bridges)

Damage Degree	Meaning of the Damage Degree	Index*
V(OK)	No problem, not shown below	100
IV	Points requiring attention, damages to similar structures, environmental factors (damage caused by salt), heavy traffic volume, aged.	80
III	Identified as Damages, subject to preventive maintenance measures.	60
II	Survey for Repairs required	40
I	Danger, urgent repair required.	20

* Numeric scale used for calculation of the health index

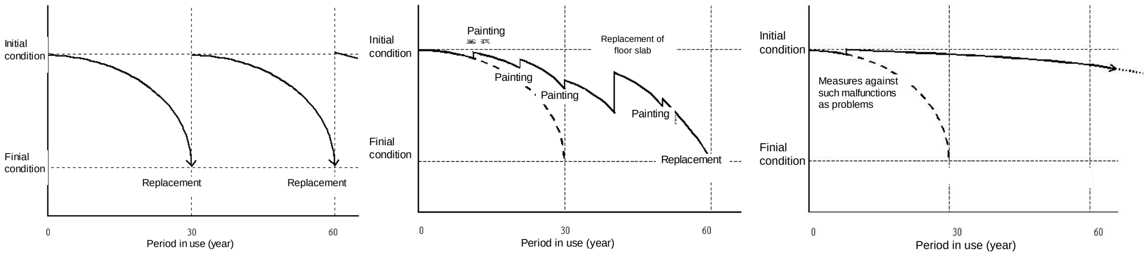
(3) Deterioration Scenarios

In managing structures, it is required to consider that the health index will change due to aging. Therefore, we have introduced the following deterioration scenarios.

It is the progress of damage to each parts and members that determines the health index. However, there is no clear understanding of the deterioration mechanism. So we assume the following three scenarios to predict deterioration patterns. These scenarios are based on expected management patterns and the period of usable life and are to be applied to each structural unit.

- Non maintenance (Disposable) scenario: a scenario to be left without maintenance and repair (30 years usable life)
- Repair when broken (Symptomatic treatment) scenario: a scenario to be repaired when damage becomes severe (60 years usable life)
- Troubleshooting scenario: a scenario in which preventive measures applied, defects completely fixed in early stages, and lifespan extended by new technology. (120 years usable life)

These scenarios enable to predict the usable life of each structure as well as estimate costs for maintenance and repair over the mid- and long-term. The scenarios introduced here are based on a survey on replacements of highway bridges held by the Public Works Research Institute and the Road Bureau of the Ministry of Construction. The survey revealed that relatively many bridges were replaced when they reached either 30 or 60 years of life. According to the more reliable data from inspections and surveys that will be accumulated in future, the scenarios will be adjusted accordingly to make the predictions more precise.



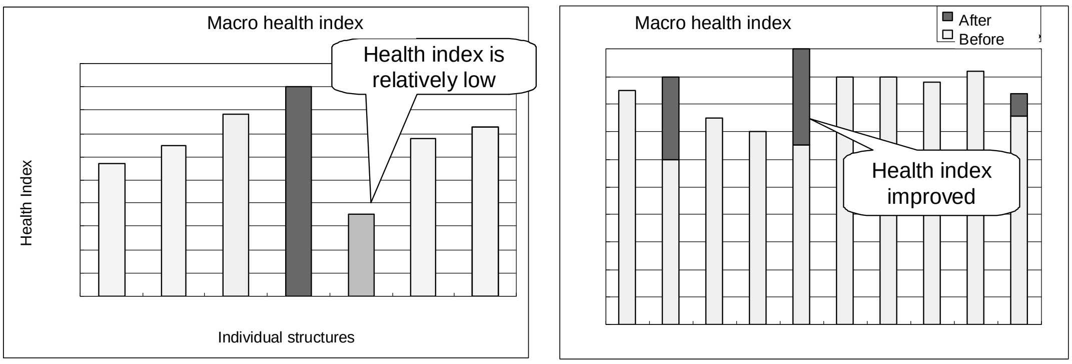
[Non-maintenance scenario] [Repair when broken scenario] [Troubleshooting scenario]

Figure 2: Deterioration scenarios applied in the asset management framework

3.2.2 Macroscopic Management

The objective of the macroscopic management is assisting the headquarters of the authorities responsible for the management of the overall asset inventory, drawing up the plans of maintenance and management, and budget appropriation.

Macroscopic management is conducted using the indicators that reflect the health of the overall asset, calculated by the health index of individual structures. In some cases, indicators express the health index of structural stock by routes or regions. The weighted average value of the

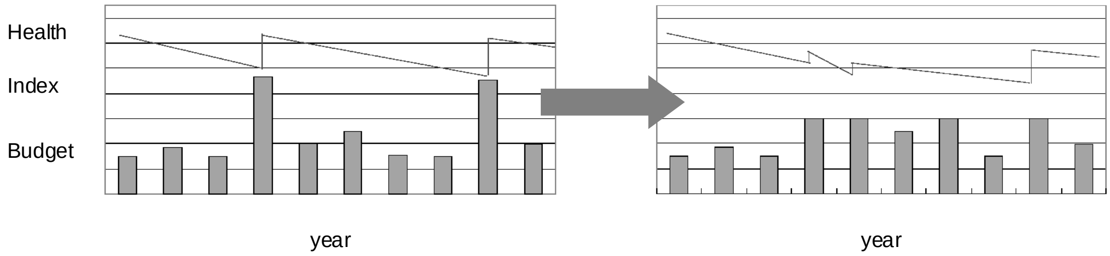


health index can be used as an indicator.

[Evaluation of structure groups] [Ex post evaluation of repair]

Figure 3: Utilisation of macro health index on the group or network management.

What is required in the macroscopic management is to set middle to long term goals based on awareness of the health index of the complete asset inventory, to enhance or maintain the health index of the overall asset, and to make decisions such as whether or not to prioritize routes and regions with lower ratings in allocating budgets.



[Sum-up of individual structures] [Equating of yearly budgets]

Figure 4: Utilisation of macro health index on yearly budget allocation

3.2.3 Communication between both Managements

The microscopic management conducts the inspection and records damage degree then makes up draft plan for maintenance and repair. It also calculates the health index. After that the budget request and data of condition including health index are transferred to the macroscopic management.

The macroscopic management evaluates priority regarding total budget allowance and asset condition shown by health index and other indicators. Then it allocates budget to the microscopic managements.

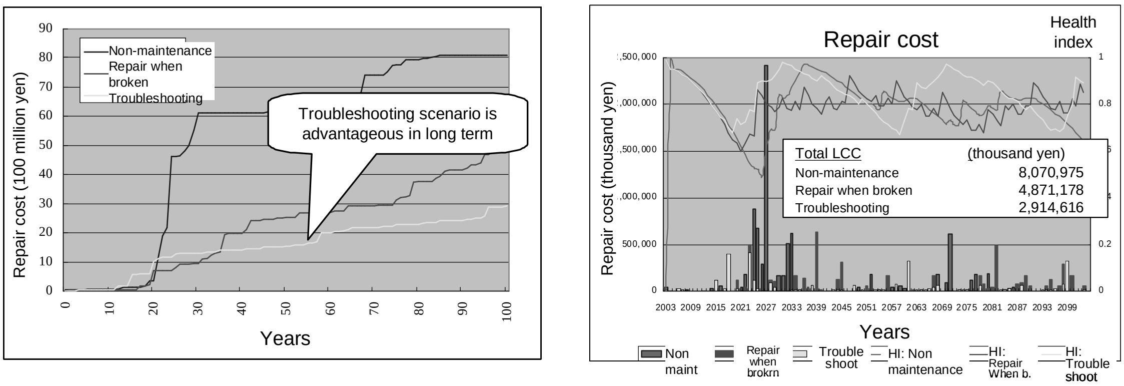
The microscopic managements revise the draft plan according to the budget allocated by the macroscopic management and carry out the maintenance and repair works. The microscopic managements conduct its activities in compliance with a set of certain rules fixed in advance. The results of the maintenance and repair are supposed to be reflected in changes in the damage degree, and further, in an improved health index. The management cycle formed by the two components works in this way.

3.3 Case Study

To show the possibility of the framework, we conducted a case study including the simulation on the data storage, the proceeding of the two management components and the data exchange between them referring the existing inspection data of national highway bridges in Hokkaido region of Japan.

3.3.1 Microscopic Management

At first we simulated the life cycle cost of individual structures applying three scenarios. In long term (over 35 years), the troubleshooting scenario becomes more advantageous than other scenarios on the life-cycle cost. As structure group, the concentration of budget requirement in several years is considerably high in two scenarios other than troubleshooting scenario. This result shows the need for the structure group management.

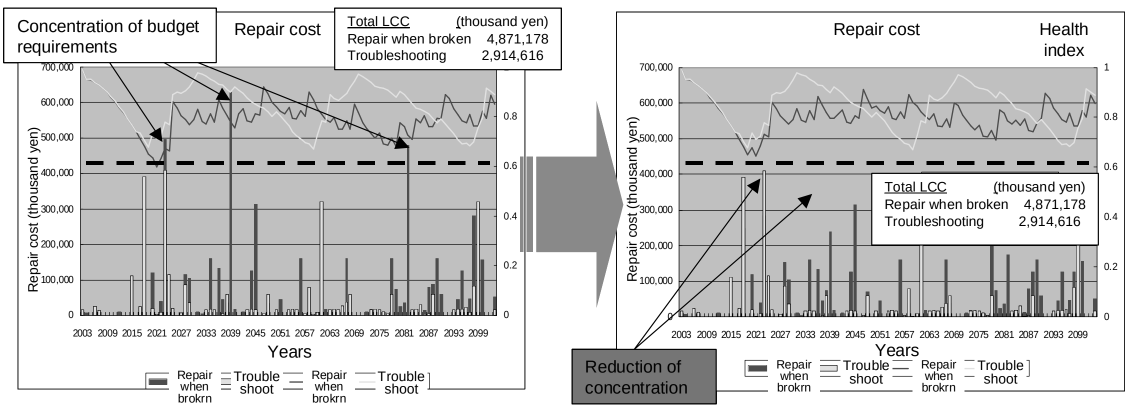


[LCC simulation of individual structure] [LCC and HI simulation of structure group]

Figure 5: Case study on the Microscopic Management

3.3.2 Macroscopic Management

We simulated the yearly budget control for the structure group by changing the scenario of individual structures which are managed according the ‘repair when broken (symptomatic treatment) scenario’ regarding the health index. The concentration of budget requirement has been reduced and the total health index has been improved after changing the scenario of several bridges. This result shows the effect of the structure group management.



[Sum-up of individual structures] [Macroscopic management applied]

Figure 6: Case study on the Macroscopic Management

4. Conclusions

Responding to the issues of the asset management of the infrastructure in Japan, we have built up a new framework of asset management composed of individual facility management and network (or group) management regarding the decision making process of the authorities in charge of infrastructure management. Then we simulated the framework with the inspection data of bridges of national highways in Japan. The simulation contains the choice of management scenarios with lifecycle cost evaluation and the optimization of long–term management including health index prediction and financial analysis.

The result of the simulation on the individual facility management showed the effectiveness of preventive maintenance and group management. These results were similar to that of simulation by existing bridge management system. So we came to the conclusion that the possibility and effectiveness of the framework have been confirmed. We will make more detailed simulations including decision of the priority between several infrastructure groups and then will make up a guideline of infrastructure asset management for the local governments of Japan.

The combined framework of the macroscopic and microscopic management introduced in this paper is based on some assumptions made for civil structures in the absence of clear information on the deterioration mechanism and it will be applicable to other infrastructure including buildings.

We expect this framework will assist the authorities in undertaking their asset management and securing the sustainable infrastructure services.

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Section III

Needs and expectations of customer

Creating a User Performance Brief: An Action Research Study

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Abstract

Pre-design processes and activities are being instituted that work through client strategic and organisational issues, needs and requirements before the design team is involved. The participation of stakeholders in pre-design workshops is a common feature of these project inception approaches. These approaches prepare a clear and workable statement of the project requirements in performance terms that the client and user groups have committed themselves to. This strategic brief (or definition of the business case of the organization) can then provide a sound basis for the documentation of the needs and provide a sound basis for the development of the design. One approach to these early stages of the project is *strategic needs analysis.* This approach uses a workshop setting to focus stakeholder involvement in proposing and identifying a range of strategic options for the proposed project. An action research study of strategic needs analysis involving a new library with community facilities is presented. The process involved with the development of organizational strategic options with the stakeholders is described. The creation and identification of user performance indicators to guide the design development process is illustrated.

Keywords: briefing, strategic needs analysis, performance indicators.

1. Introduction

A number of approaches have been and are still being developed that aim to assist in creating alternative strategies during the development of policy in the early stages of project inception (Best and de Valence, 1999). These techniques aspire to develop a process that converts the organisational strategy into property investment decisions or corporate real estate that support them. Indeed, Green (1992), Latham (1994) and Egan (1998) have highlighted the need for skilled specialist practitioners to bridge the gap between corporate strategy and the development of building projects to realize their strategy.

The literature (Latham, 1994; Egan, 1998; Smith, 1998) has noted an established gap between the design process and the construction activities further down the development process or supply chain as the more recent literature terms it. However, this research focuses on the second gap between the strategic management in an organisation and the subsequent design development activities. A number of authors (Gray and Hughes, 2000 and Walker, 2002) have indicated that there is a gap between the pre-design activities and the design stages.

So, in contemporary terms the supply-chain exhibits discontinuity at two critical points: firstly, when a project passes from the strategic decision to build to the design stage and secondly, when it is translated from a design *model* into its built form at the construction stage. These gaps are illustrated in Figure 1. The emerging solutions to greater integration between design and construction are noted together with the focus of this work, the potential approaches and techniques that are being developed to close the gap between strategic management and the definition of a project for the design stages.

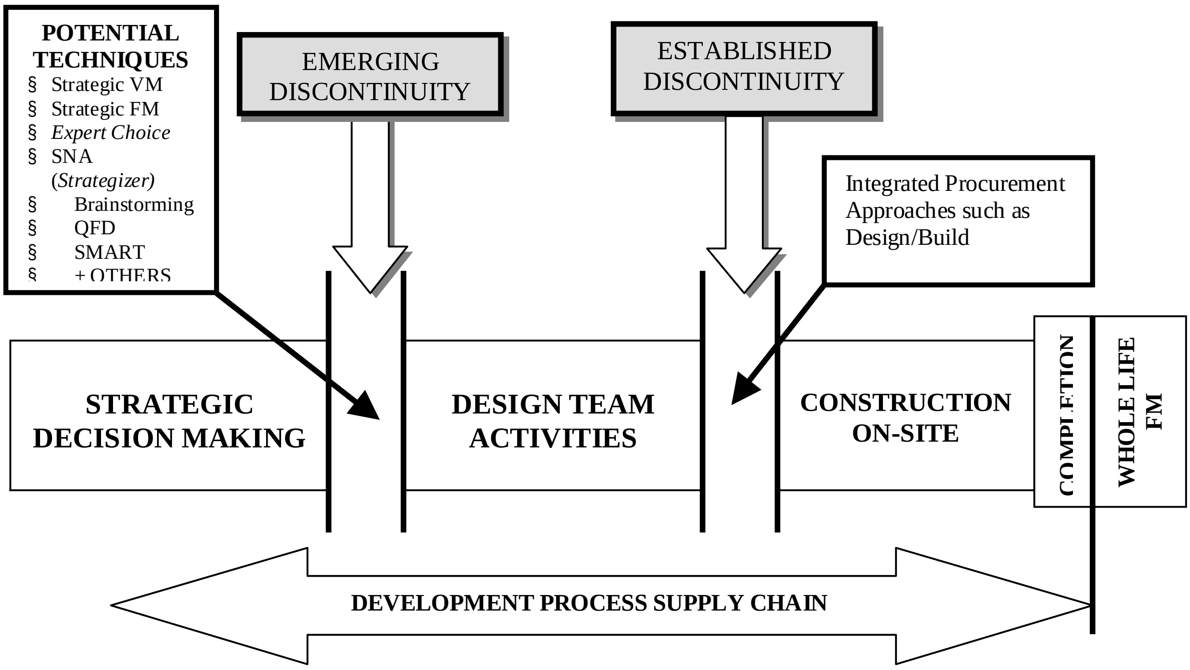

Figure 1: Discontinuity in the Development Process Supply Chain

The consequences of this first gap, between the strategic and design, after the decision to build has been taken at the strategic level, is that this decision may not be informed or supported by senior management or from a broad a range of ideas and views from stakeholders (users) as is possible. The possible insular approach adopted by the senior managers could result in an administratively easy or convenient decision that is not necessarily the best one. It seems to be more difficult for senior management when stakeholders are genuinely involved giving their ideas, views and suggestions for developing alternative strategic options. Senior management often are left with the freedom to make a decision to build, but it is likely to be a decision lacking comprehensiveness, clarity and authority. The design team naturally fills any information voids and makes its own assumptions to provide the necessary performance and user characteristics. So, when the decision passes to the design team it may result in a project decision that exists in a vacuum. It may be convenient for the design team to begin the process with a *clean sheet*, but the alternative view is that to disregard the strategic and stakeholder issues and information that contributes to the design team being poorly briefed and informed on all the factors influencing the project.

The closing of the gap or reduction in discontinuity should be achieved by adopting some of the recommended action for the strategic and stakeholder category attributes for the project inception process given in Figure 1.

A process is needed that can make a valuable contribution to the strategic stages in project inception. The process should confirm and extend the decision to build (new-build, extend, renovate, upgrade, remodel). It must reflect the environment of the organisation by being sensitive to the strategic direction identified in the strategic management process by capturing the mission, vision and values expressed by the organisation (Woodhead and Smith, 2002). These must guide the process of considering alternatives to satisfy the strategic direction already determined. The process must also be useful, flexible, well organised, sensitive to client and *stakeholder* needs and objectives and designed to provide more effective, efficient, innovative and better solutions (Karma and Anumba, 2001). Some notable attempts have been made to import existing techniques such as the *SMART* methodology (Green, 1990), *Expert Choice* or the analytical hierarchy process (Saaty, 1990a, 1990b; Yang and Lee, 1997), Quality Function Deployment (Akao, 1990; Kamara, et al, 1999), AdePT (Austin, et al, 2000) and value management (Thiry, 1997).

2. Strategic Needs Analysis

A number of approaches are listed in Figure 1 and these are expanding as new techniques are being developed. A model termed, *Strategic Needs Analysis* (SNA) was developed and adopted. SNA was designed with the characteristics noted above in mind and with the aim of making a positive contribution to the inception of a project. It also starts with the premise that the solution delivered will be the most appropriate to satisfy the stakeholder's strategic needs and this is likely to be, but may not always be assumed to be a construction project. Strategic Needs Analysis is designed to make a valuable contribution to this important formative stage of a project. It reflects and is sensitive to the strategic direction identified in the strategic management process and so overlaps it. Indeed, strategic management (Thompson and Strickland, 1995 and David, 1997) and problem solving approaches (Ackoff, 1978) have greatly influenced the development of this approach and it is designed specifically for the concept or project inception stages of a project.

The author used the SNA approach as a means of assisting in closing the gap between strategic decision-making and design team activities. However, from the author's research (Smith and Jackson, 2000, 2003 and Smith and Love, 2004) progress can only be achieved with the cooperation of the senior management that makes and implements the decision to build. A proposed solution to provide greater integration of the strategic with the project inception activities using SNA is shown in concept form in Figure 2. This Figure brings together the disparate elements of decision-making within an organisation at the various levels and attempts to integrate it into a framework that recognizes the decision to build is part of the strategic and operational (and facilities management) environment.

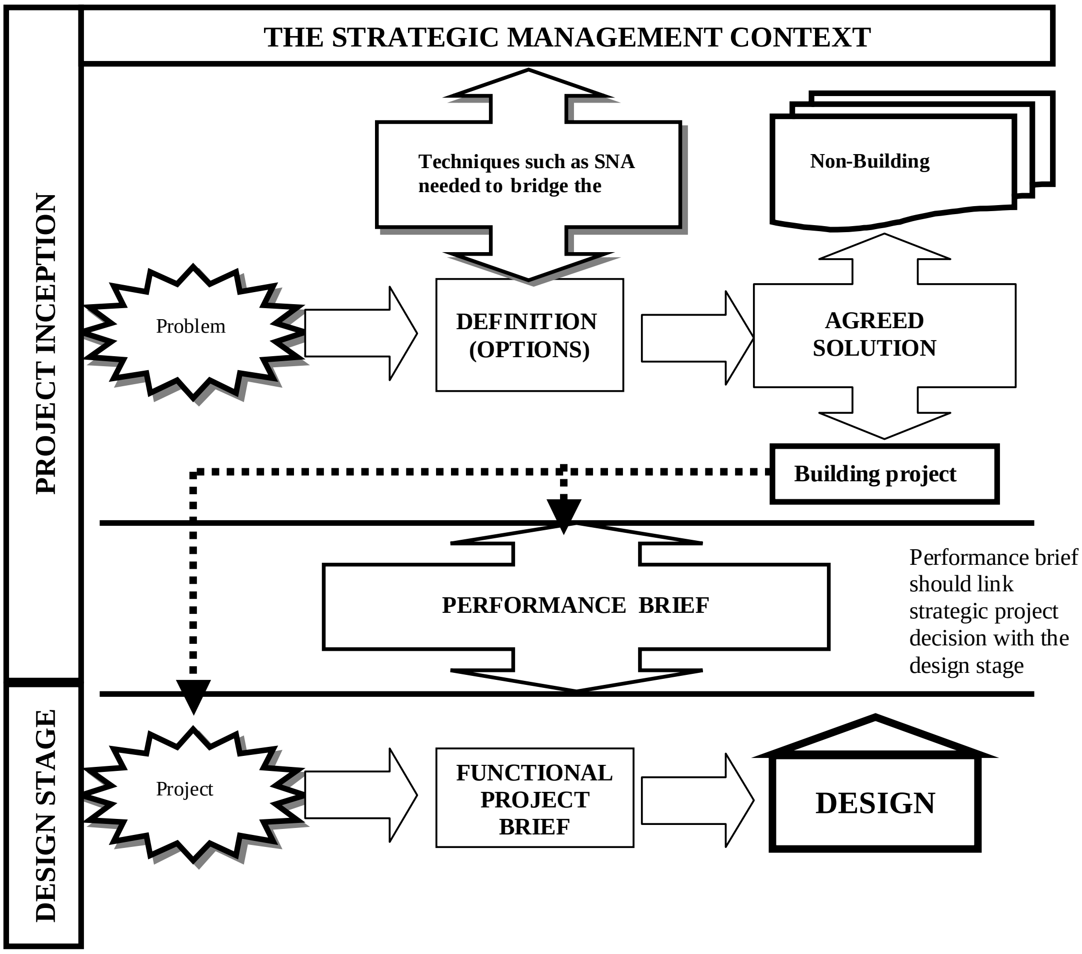

Figure 2: Linking the Strategic to Project Inception

Naturally, after its development and testing the author believes that SNA in conjunction with *Strategizer* can deliver a better way of defining client and stakeholder requirements. These can be captured in a performance brief that properly describes the client group needs and requirements in a form to give direction to the design team, but does not hinder their creativity nor their ability to explore alternative ways to satisfy the strategic performance requirements documented more explicitly by SNA.

3. The Study

This study was based on the analysis of the feedback from the evaluation surveys, the test analysis and personal observations about the process gained from five previous action research studies. (It is beyond the scope of this paper to describe action research in detail. For details of the action research approach see Barton-Cunningham, 1993 and Babbie, 1992). These earlier studies provided the means and the vehicle for the testing and development of SNA and guidance for making changes to the organisation of the SNA workshops and use of the *Strategizer* software in this study.

In this test study the author decided to test and gain assistance from an additional computer software program, *Situation Structuring*. From informal author test trials this software appeared to have the potential to assemble, or cluster, seemingly disparate characteristics and performance requirements (called elements in the software) into related groupings after interrogating participants on their views of these characteristics. The designer of *Situation Structuring* is Dickey (1995) and the software is described in Wyatt (1999). Diverse elements of a problem (people, places, objects) are combined into coherent groups. This enables these simpler and more manageable groups to be considered one at a time. By carrying out such an analysis the process provides a trade-off between simplicity and homogeneity (Dickey, 1995).

The software has been designed for generic problem-solving environments and this author believed that such a process could assist in the grouping of the range of participant identified themes from the workshop brainstorming session. These groupings would then form the basis of an agreed range of options for scoring by *Strategizer* at the end of the first workshop. *Situation Structuring* software could thereby provide the important link and technical structure to the critical process of options development and agreement.

3.1 Project Context

The Corporate Assets Manager of a local government council located in an eastern middle suburb of Melbourne (around 10 kilometres from the CBD) contacted the author. He felt that a SNA would be a useful process in identifying the nature of a proposed Library-Community complex with its potential uses involving a range of stakeholders who may be able to identify new opportunities for the new Centre at this critical stage in the planning and development stage of the project.

3.2 Aim

The aim was to develop a strategy that would take into account the needs and opportunities available from developing a site in a declining neighbourhood shopping area (known as an Urban Village). The wide ranging review required by SNA would involve a number of stakeholders from which the Corporate Assets Division (in conjunction with the author) could eventually prepare a performance brief for the agreed strategy.

3.3 Stakeholders

The Corporate Assets Manager organized the number and type of participants invited to attend the workshops. There were 15 participants in workshop one and 13 in workshop two. No external stakeholders (that is, outside Council employees or representatives) were invited or included in these activities. Four divisions within the Council were represented in each workshop; Corporate Assets, City Development, Business Development and Human Services.

4. Workshop One Summary

This workshop took place in a meeting room at the Council Offices. The process in workshop one is summarized in Figure 3. The participants were encouraged to identify the characteristics and their concerns about the project. No attempt was made at this early stage to limit the concerns. Once the full list of stakeholder concerns were identified and described they were then reviewed and discussed by the group. This produced a more refined and redefined list of concerns with fewer overlaps and repetition of the same concept. The refined list reduced the stakeholder concerns from 17 to 15 in number. These were summarised and are listed in Table1.

The fifteen refined stakeholder concerns above were measured and analysed by the group within the *Situation Structuring* software (Dickey, 1995; Wyatt, 1999). This analysis produced three groups of linked or related concerns. The features of these three common groupings were discussed and eventually placed under working titles chosen by the author to reflect their common approach or relationship. The titles, keyword descriptions and characteristics agreed by the participants under the common groupings are summarised in Table 2.

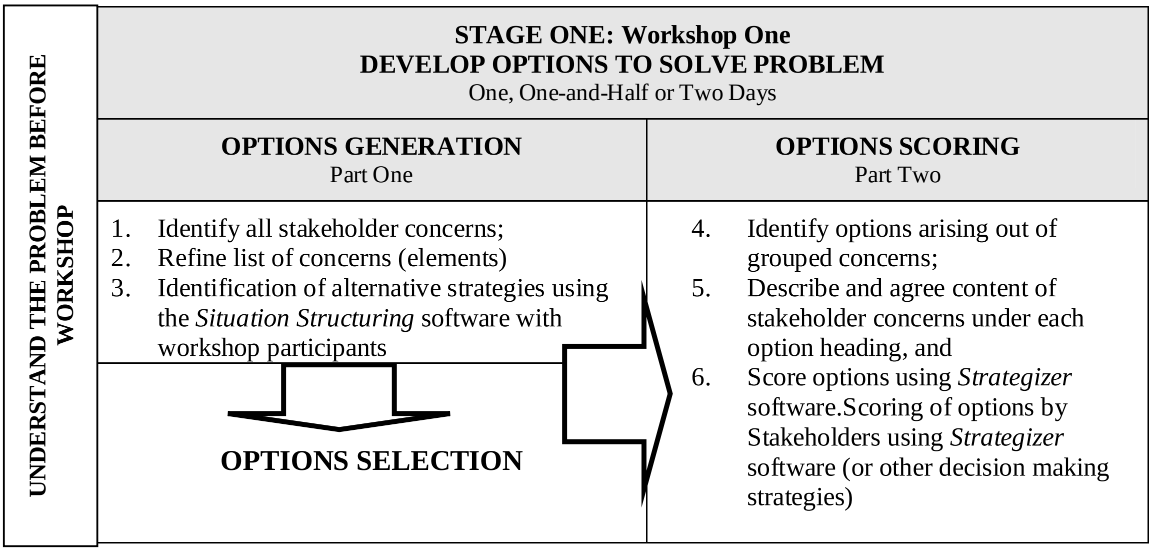

Figure 3: Workshop One Activities

Table 1: Stakeholder Concerns Defined and Refined

Identified Concerns	Refined List of Concerns
• Provide a sense of ownership	1. Interrelationships between uses
• Efficient / effective facility	2. Profile of council
• Adaptable/flexible facility	3. Service delivery
• Civic presence	4. Extent of commercial uses
• Recognition/local context	5. Commercial viability
• Satisfy community needs	6. Council viability
• Help create a sense of community	7. Sensitivity
• Enhance service delivery	8. Community ownership
• Improve/redevelop neighbourhood appearance	9. Accessibility
• Enhance economic viability of village	10. Flexibility
• Improve access	11. Effectiveness of individual service
• Distinctive sustainable environment	12. Sustainability
• Emphasis on people	13. Environmental efficiency
• Expand space for uses	14. Security
• Replace under performing/obsolete facilities	15. Diversity
• Reflect diversity of community	
• Change/grow to reflect community	

The participants concentrated on each stakeholder concern in turn. Details of the content of each concern was discussed, agreed and documented during the workshop using an electronic whiteboard. The finally agreed content of each concern is given under the appropriate option heading in Table 4. The three options (Workable, Council Perspectives and Community Satisfaction) group the stakeholder concerns as noted by the group and listed above in Table 4 were agreed by the participants.

Table 2: Details of Options

OPTION 1 **Workable**	**OPTION 2** **Council perspectives**	**OPTION 3** **Community satisfaction**
Efficient, Effective, Pragmatic	*Building Statement, Civic Presence, Best Practice*	*Integration, Belonging*
• Service delivery	• Profile	• Sensitivity
• Flexibility	• Extent of commercial uses	• Community ownership
• Sustainability	• Council viability	• Accessibility
• Security	• Environmental efficiency	• Diversity
• Interrelationship between uses	• Commercial viability	• Interrelationship between uses
• Effectiveness of individual service		

The participants also believed that in the first section, *Workable*, under the category of *service delivery* there should be further elaboration of uses into of existing uses and of potential uses that should be considered in the development of the new facilities. These were developed, agreed and are shown in Table 3.

Table 3: Service Delivery: Identification of Existing and Potential Uses

EXISTING	**POTENTIAL**	
§ library	§ service centre	§ immunisation
§ youth services	§ business/commercial use	§ information on council
§ playgroup	§ meeting space	§ library administration
§ three-year old activity	§ maternal and child health (outreach)	§ toy library
§ neighbourhood program	§ education training rooms	§ display area
§ senior citizens	§ business *incubator*	§ council adult learning centre
§ open space	§ library program and events	§ coffee shop
	§ residential accommodation	§ internet café
	§ visiting services	§ post office

The Workshop also discussed the inclusion of a number of *wildcard* options to test the demand for a non-conventional approach. A *Do-Nothing* option was rejected because it was agreed that from the ideas and commitment of the group that such an option would serve no useful purpose in the analysis in this situation. The four wild-card options suggested were; Outdoor performance space, Leisure Activities centre, High Rise Approach (with potential for more high density residential apartments) and Transportation Hub (linked with buses and railway station).

After a brief discussion it was decided that the final two options only (High Rise and Transportation Hub) would be included in the final list of options. The *Outdoor performing Space* was deleted by the participants as it was felt not to be a comparable option to the others. All the five options noted include the provision of the library, but with distinctive emphases in the joint development. The final list of options scored by all workshop participants in the *Strategizer* software at the end of the workshop were; WORKABLE, COUNCIL PERSPECTIVES, COMMUNITY SATISFACTION, HIGH RISE and TRANSPORTATION HUB.

Participants then scored each of the five options privately and individually on the *Strategizer* software. The scoring process brought workshop one to an end.

5. Workshop Two Summary

After a short break of five days workshop two was convened to finalise the SNA process. The steps required to complete the SNA in workshop two and to complete the performance brief are summarised in Figure 4. A major activity was to decide on a preferred strategy after the results of the scoring of the options was presented by the workshop facilitator (the author).

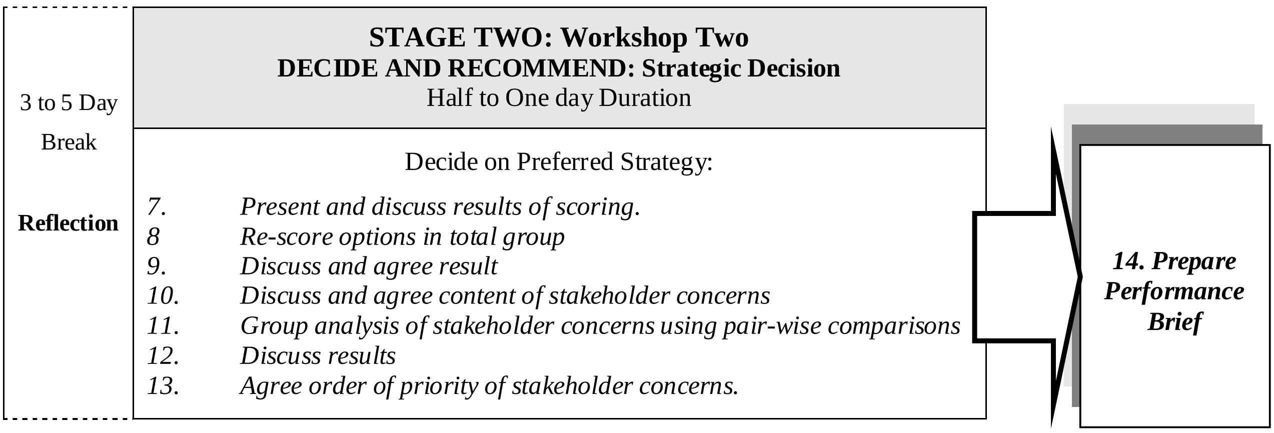

Figure 4: Workshop Two Activities

4.1 Options Scoring

When the Options' scores of all participants were analysed they showed the following results for the five options. See Table 4 for details of the scoring for each option.

Table 4: Options' Scores: All Participants

OPTIONS	WORKABLE	CIVIC	COMMUNITY	HIGH RISE	TRANSPORT HUB
AGGREGATE	3.8	3.5	3.8	-2.5	-1.6

A review of Table 4 indicates that the late entrant options, "High Rise' and 'Transport hub' did not fare well in the scoring. They have high negative scores and compared to the other three options (with positive scores) and so were not considered as serious options in the final analysis.

The participants in the workshop decided that the results were not conclusive enough to favour any single option. All three options were so close it was agreed that the characteristics or concerns from each option should be blended into the final performance brief for the project. The selection of a single option from the ones developed was, therefore, not considered. The workshop agreed to concentrate on first of all, refining the stakeholder concerns developed in workshop one.

The workshop group reviewed the list of fifteen stakeholder concerns and decided to prioritise these to provide the design team with guidance about their strength of feeling towards each one. The group then made a paired comparison of each concern scoring one concern against the others in turn on a ten-point scale running from, *overwhelmingly more* (9) to *overwhelmingly less* (0).

The workshop group then discussed and reviewed the final analysis based on the pair-wise comparison and agreed that it fairly represented the group's order of priorities in their stakeholder concerns. The group then agreed that the listing of stakeholder concerns provided a sound basis for developing the *Performance Criteria* for the proposed project. Rather than give each of the criteria a single priority it was decided to group the criteria into three levels of priority. These are given in Table 6 below with the individual criteria listed against each level.

Table 6: Priority Levels and Performance Criteria

PRIORITY	CRITERIA
1. Key Performance Criteria: PRIORITY ONE	Service Delivery Accessibility Security Council Viability Effectiveness of Individual Service
2. Essential Performance Criteria: PRIORITY TWO	Interrelationship between Uses Flexibility Community Ownership Sensitivity of Urban Design
3. Significant Performance Criteria: PRIORITY THREE	Diversity Sustainability Environmental Efficiency Commercial Viability Profile of Building Extent of Commercial Uses

6. Outcome

A Performance Brief was prepared based on these criteria. The brief was prepared within one week of the completion of the workshops and sent to the client for any additional Council and service department detail to be provided by the participants. The detail on each criterion provided by participants in the workshop provided the basis for the detail included in this performance brief.

The library project reached a hiatus soon after completion of the SNA. The draft performance brief was reviewed by the Corporate Assets Division and few minor changes and additions were made. This brief was then approved by Council a few months later and the agreed performance brief then formed the basis of calling tenders for design consultants. Consultant architects were appointed and outline proposal drawings for the scheme were completed in October 2002. Final documentation of the project was completed in September 2003 after more consultations with the community and delays in the compulsory acquisition of adjoining properties. The tenders were called in early 2004 and construction work started in June 2004. The project is expected to be completed in mid-2005. The activities and interactions following the completion of the performance brief were monitored and analysed by Heywood. A summary of the total process (now identified as the *Glen Eira model)* is given in a companion paper by Heywood and Smith (2004).

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Bridging the gap: Exploring expectations and perception-based performance assessments

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Abstract

The Facilities Management (FM) literature has identified that bridging the gap between expectations and delivery of service (performance) is crucial in successful Facilities Management that meets client needs. This gap between expectations and evaluations of service delivery contains an implicit assumption that both sides of the gap are objective and measurable. However, assessments of service delivery and the facilities themselves are not wholly objective. Assessments contain substantial subjective components, which are frequently labelled ‘perceptions’. The existence of subjectivity makes bridging the gap difficult for FM practitioners when relying solely on objective measures.

New facilities frequently catalyse expectations and perceptions. The research examines the pre-construction phase of the provision of a new local government library-community centre facility in Victoria, Australia. This paper aims to identify the psychological basis of subjective assessments that Facility Managers meet in their practice, and thereby provide a more comprehensive understanding of the basis of performance evaluations in Facilities Management.

The research used a case study based qualitative methodology. Within the methodology a psychologically classified lexicon was used to analyse the case’s data. A variety of data sources was used, including project documents and interview transcripts. This paper concentrates on data pertaining to briefing related activities.

The study’s findings furnish detailed evidence of the affectively based subjective components that exist in assessments of this facility; be that expectations of the facility or evaluations of how it will perform through meeting the brief. These results do show the subjective basis of expectations and evaluations of facilities, and in doing so, provides the comprehensiveness of understanding sought.

While specific to local government, the study is of interest to Facilities Management practice generally where meeting user expectations are key parts of assessing the performance of facilities and their management processes. In addition, the analytic framework used in this study provides a means for analysis to reveal the foundational basis of assessments of facility performance, thereby enabling a bridging of the gap between expectations and subjective evaluations of performance.

Keywords: Expectations; local government; perceptions; performance; psychology,

1. Introduction and positioning the problem

The following statements are probably familiar to many facility, or corporate property managers.

> 'It doesn't matter what facts you give them, the decision-makers decide using their own perceptions with who knows what criteria. The same could be said of our facility users.'
>
> 'In local government perceptions are everything.'[1]

These comments describe informal, subjective evaluations which, from a facility manager's perspective, often usurp their arguments for any given facility management decision. As such, they starkly illustrate the difficulty of bridging the gap between expectations and such evaluations of performance from facilities and their management. The Facilities Management (FM) literature has identified that bridging the gap between expectation and delivery of service is crucial in establishing successful FM that meets client needs and notes the importance of communication in that process [1] but contains an unstated assumption that achieving the service will satisfy. Delivery may constitute either FM service or the facility itself. This paper discusses the delivery, or provision, of a facility but could equally apply to other aspects. Little FM literature has been identified addressing differences in expectations. Hinks and McNay [2] is a notable exception. Means by which expectations are utilised in bridging the expectation-perception gap has been found in other service-based fields, for example Sawin [3].

It is an assumption that that both sides of the expectation-service delivery gap are objective and measurable. The use of management tools such as goals, aims, Key Performance Indicators, and even strategic management are indicative of attempts to objectify business outcomes [4]. FM research and practice has expended much effort in attempting to derive measures of facility and FM performance (Amaratunga [5] is fairly comprehensive as is Hinks and McNay [2]). However, definitiveness remains elusive, especially in light of observations regarding the number of new FM services introduced in a recent year, which is probably not atypical of other years [6].

Expectations and evaluations of performance are rarely wholly objective, as evidenced by the introductory comments, being, at times, quasi-subjective. In such circumstances, reliance on objective measures as proof of performance will invariably fail to completely satisfy evaluators of performance conducting formal or informal evaluations. Furthermore, objective measures of performance count for little if they are evaluated through subjective lenses. In addition, expectations and evaluations of performance exist, not so much as opposite ends of a process but with experience from previous evaluations contributing to expectations carried into future evaluations. To complicate it further the literature shows that professional and lay evaluations differ markedly [7, 8].

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[1] These paraphrase comments made by this research's local government industry partner and are probably not peculiar to local government.

Previous research by the authors has shown the *affective* (emotional) basis to such heated facility evaluations as the 'Not in my Back Yard' (NIMBY) phenomenon [9]. For professionals, these are difficult responses to facility matters and often labelled 'irrational', or 'subjective' [10], or may be thought of as 'too hard', variable and unreliable for use [11]. In FM's case the basis of this thinking may be attributed to the operational and technical origins of the profession [12]; the technical-rational bases of many professions [13]; and the reliance on often financial measures in order to appear business-like [14]. The foundation of such categorisation as irrationality is undermined by Nussbaum [15] suggesting that *affective* (she uses emotional) responses are reasonable, direct indicators of, or responses to, threats to human well-being, or flourishing. For providers of facilities to support well-being, such as local government [16], such responses should be of interest.

The subjectivity of both expectations and evaluations of performance (perceptions) is due to their involving psychologically formed attitudes and beliefs, in addition to the role of psychological functions in processing environmental stimuli. Environmental psychology has worked extensively on evaluations of physical environments, but considerations of environmental management (such as Facilities Management) are largely contained to such issues of 'green' or recycling behaviour. A tripartite basis of psychological functions is well established in social psychology [17]. The three functions are – *Cognition*, *Affect* (or emotion) and *Behaviou*r (or conation). These same three functions have also been shown to be constitutive of attitudes and beliefs [18].

Furthermore, psychological processes do not operate autonomously but intervene on each other. For instance, mere exposure to something has been shown to induce *affective* responses (liking) which alters *cognitive* evaluations [19]. Also, *behaviour* based psychological therapies operate on the basis of changes to *behaviour* induce corresponding changes to attitudes and cognitive processes, for example [20]. In addition, the psychological functions show longer-term frames of mind, or more transient states and state-like conditions [21, 22].

2. Aim

New facilities frequently catalyse expectations and provide evaluative situations. This paper examines the psychological basis of subjective assessments within the provision of a new local government library facility in Victoria, Australia. The paper aims to show how *affect* is present on both sides of the expectation-evaluation gap providing an understanding of the foundational basis of performance assessment in Facilities Management.

3. Method

The study's methodology is a psychological based orientational qualitative enquiry [23]. Case study is the principle research method as this is most suitable for context embedded research such as this [24]. The case is from an inner to middle suburban Melbourne municipality, and is a current construction project. Within the case study a variety of data gathering methods are used – documentary analysis of Council's public statements and Council management documents; interactions with the research industry partner; participant observation in consultation meetings; time as a municipal resident; and interviews with Council service delivery and project management staff (including the external design team).

Coding methods are used to analyse the resulting textual data [25] with QSR's qualitative software *nVivo* used to assist coding activities. An *Affective Lexicon* [21, 22], based on the psychological typological classification in Figure 1, below, was used the basis of coding the *affective* content of language data (text). The *Lexicon* was formed from words the literature considered to be emotions. Text was analysed on the basis that the text acts as a record of emotion, in the absence of emotion's visual, neurological, or olfactory detection. The lexical structure includes categories for *affective evaluations*, the psychological functions (conditions) as *frames-of-mind* (longer-term dispositions), *states* (brief, temporally bounded), and *state-like* (similar to but not explicitly states) conditions. Inter-linked conditions, such as *affective-cognitive conditions*, are also provided.

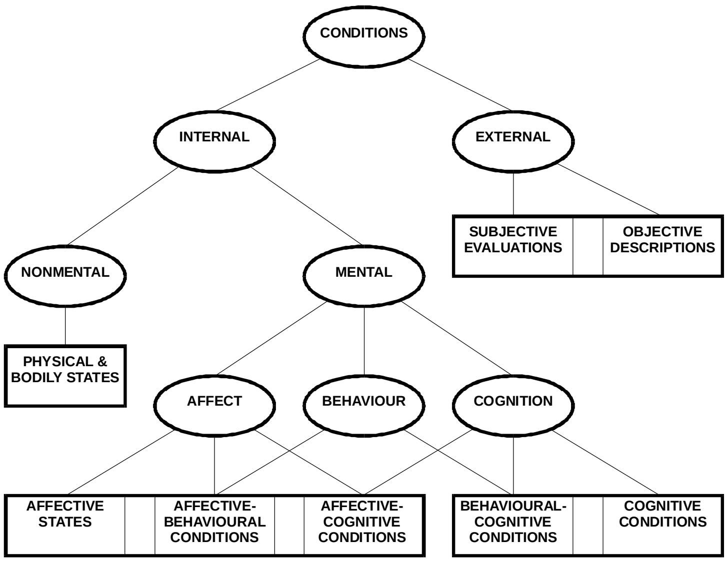

Figure 1: Psychological typological classification (after [21])

Additional categories such as *non-affective evaluations*, *Other cognitive*, and *Other behaviour*, have been added during the course of this research as they are absent from, but are consistent with the lexical structure. In the text below, words from the *Lexicon* are **bolded** while the typological classification is shown in *italics*.

Results for all three stages are tabulated together in *Appendix 1* but they are referred to throughout the paper.

4. Empirical study

The case studied is a new municipal Library-Community Centre to be constructed within a municipal 'Urban Village'. The client, as represented in the facility management function, may be considered a 'Secondary constructor' of a moderately 'Experienced' type (Walker [11] citing Masterman and Gameson [26]).[2]

The facility has, at least, two user-client types with Council service departments (primarily, library and local child services) consisting one, and community groups relocating into it, the second. As the introductory comments indicate the municipal Property Management was aware from previous experience that 'perceptual issues' exist in providing this facility. To address and manage the perceptual issues a two-stage facility provision process was adopted.[3&4]

Construction is not complete at the time of writing, therefore this paper only reports pre-construction processes contained within Briefing activities. These consist of three stages – the project's *Performance Brief*, the developing of that *Brief* with additional information from brief-building consultations with project stakeholders, and thirdly, reporting to stakeholders of how the building design met the brief from both Stages 1 and 2. The three stages capture expectations in the first two stages and, in the third, an evaluation of how they have been addressed. Incidentally, the third stage, also, contributes to the sum total of expectations that will be met in the post-completion evaluations, be they formal Post-Occupancy Evaluations or the 'informal' human assessments that are of interest to this research. Post-completion evaluations are beyond the scope of this paper.

4.1 Stage 1 – Council officer (client) expectations & developing the brief

In the first briefing stage the facility proposal was studied using pre-briefing Strategic Needs Analysis (SNA) methods [27]. Workshops with participants from stakeholder groups within Council administration responsible for possible tenants, or Council's strategic interest groups (such as municipal Business Development) lead to the development of three options with clustered strategic priorities – Option 1: Workable; Option 2: Council Perspectives; and Option 3: Community

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[2] This classification system [26] is useful in understanding this municipality & local government generally. Local government falls towards the extremity of being 'Secondary constructors' (with this classification becoming known as Corporate Real Estate in recent years) but the level of the experience may vary and will frequently be linked to the level of experience of individual managers – both asset and service delivery. An issue for local government, and the factor that moves it away from the 'Experienced' end of the spectrum, is that individuals in local government Corporate Real Estate management may be experienced constructors but with limited experience of each type of local government facility, as each is built infrequently. It is feasible that local government 'Constructors' may then over-estimate their experience and assume that they do not need to acquire the experience by type also. This was not the case for the project studied.

[3] Linder and Peters [30] state the selection of such instruments may be traced to the perceptions of individuals in a position to choose about instrumental performance, regardless of its empirical record (similarly to previous discussion).

[4] It must be noted that this process was preceded by previous Urban Village consultations at two levels – overall concept and land use planning changes, so awareness of the facility proposal was at large in the municipality.

Satisfaction [27, 28]. These were then developed into a Performance Brief [29] subsequently adopted by the municipality in briefing the architectural design team for the new facility.

The Council officers, in providing a *Performance Brief* containing these strategic priorities options,' are providing both the performance parameters against which the facility may be assessed, or tested, and documenting their expectations of what the facility will provide for their municipality by way of function and as the embodiment of values. Analysis of these priorities using the *Affective Lexicon* reveals the psychological content of those expectations. Approximately 30% of the terms have *affective* content (Table 2, Appendix 1) Very few terms are psychologically based (Table 4, Appendix 1) but three-quarters of the *affective* terms are *affective objective descriptions* (Table 5, Appendix 1). These are statements that are resolvable by reference to facts [21].

Some of the priority expressions have complex content and have multiple connections with the classification categories. Typical of this is **Security**, which has two *affective* senses. In the first instance, **Security** relates to the sense of keeping something **safe** or providing safety. '**Safe**/safety' is an *affective objective description*. For a facility, the facts of safety may be tested or ascertained with questions such as:

- Does it have doors? Are they lockable? Where are the locked doors located relative to entrances?

These are all questions are all answerable in a factual form.

In the second sense, **Secure** is an *affective-cognitive state-like* phenomenon being an *internal mental (psychological) condition*. It is *affective* in that it has immediacy and value. It is *cognition*, being a way of thinking and the two conjoin in an 'emotionally toned way of thinking' [31]. The sense here for facilities relates to the psychological sense of **security** engendered by the environment, similar to the notion of *Defensible Space* [32].

4.2 Stage 2 – Developing the brief

The second Briefing stage added further input from Council internal stakeholders and groups outside Council – user tenant groups, adjoining residents, and shop-traders. Records of expectations and evaluations in this second stage are harder to find. Memos that record the results of consultation with non-Council stakeholders, by and large, appear to record factual material useful for establishing physical parameters for design. An impression aided in its formation by their introductory paragraphs that states, in part:

'The discussions were directed to focus on the layout and design issues of the facility .This memo is concerned only with those aspects that translate to design and layout.' [33]

However, the introductory paragraph opens with:

The discussions were led around patterns of use and nature of visits to the facility and the adjoining shopping centre; aspects valued about the existing facility, aspects considered able to be improved or **dislikes**, and features considered **desirable** to be included in the new facility [33].

dislike (*affective state-like condition*), **desirable** (*affective-cognitive state*)

Thereby, flagging the *affective* basis of the memo's content.

These memos constitute the record of user expectations, because having been specifically asked it is reasonable for them to expect the needs will be met in the new facility, unless negotiated otherwise.

Analysis of the memos yielded 153 connections between the Brief-building consultation data and psychological categorisation of which 51.0% have *affective* content (Table 2, Appendix 1). This is surprising given the stated purpose as records of matters of fact for design and initial reading as being very 'matter-of-fact' in presentation. Of the statements 32.7% have *affective external condition* content of which the vast majority are *affective objective descriptions* (Table 5, Appendix 1). This conforms to the documents acting as records of facts to be incorporated during design processes. This is augmented by an additional 31.4% that are *non-affective external conditions*. The expressions that relate to *internal mental conditions*, those with psychological content, (31.4%) the majority (18.3%) are *affective* expressions compared with 13.1% *non-affective* expressions.

4.3 Communicating meeting the brief

The third stage of the Briefing process provided data from participant observation notes taken during verbal presentations to stakeholders at the end of tender documentation. The content of those presentations, which the notes record, consisted largely of descriptions of the building made while presenting the project drawings. These constitute the project consultant's evaluation of what the building will be like and how it meets the brief.[5] Analysis of this data provides 143 connections between the descriptions of the building, or a building element, and the categories of the *Affective Lexicon*. The descriptions contain both a descriptor (an adjective) and a described object, which were then coded. In most instances the descriptor was most influential in coding.

The data is almost evenly split between *affective* and *non-affective* categorisations (Table 2, Appendix 1). A few (1.4% of total) *physical and bodily states* exist but have a minor effect on the 50:50 split between the two categories. In this aspect of the Briefing event the vast majority of the *affective* statements are *external conditions* (90.0%) (Table 5, Appendix 1). This is the highest level of *affective subjective evaluation* seen in any of the three stages constituting 90.0% of the *affective*, though in Stage 1 was 84.8% of the *affective* content (Table 5, Appendix 1). Of the *affective external conditions* the majority (28.0%) are *affective subjective evaluations*.

4.4 Affect across the assessments

Examples of *affect* in assessments were introduced in discussion of classification categories in Section 4.1. Exemplifying this across the three Briefing stages illustrates *affect* on both sides of the expectation-evaluation gap. The following example (Table 1) is illustrative.

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[5] It is possible to interpret this exercise as 'selling' the design, but given that the presentation observed was the last in a sequence throughout the pre-construction period it is reasonable to state that the design had been 'sold' well before this point.

Table 1: Affective assessments across the expectation-evaluation gap

Stage 1	**Stage 2**	**Stage 3**
Sensitivity Two appearances in the lexicon	**Soften** the visual appearance of building towards neighbours (being considerate)	Domestic (building appearance and scale) Not in the *Lexicon* but usually used in the **Sensitivity (considerate)** sense in environmental descriptions
Sensitive (easily hurt) (*affective-cognitive frame of mind*)	**Comfortable (physically)** (*physical and bodily state*) for the many aged users and occupants (The design is considerate)	**Friendly** to the community (and neighbours) (*cognitive-behavioural frame of mind*). Also a synonym of **Sensitivity (considerate)**
Sensitivity (considerate) (*cognitive-behavioural frame of mind*)	**Serenity** (in the décor) (*affective state*)	**Comfortable (physically)** (stair) for occupants (*physical and bodily state*) Not **offensive** (colour scheme) (a synonym of **bad** (*affective subjective evaluation*) **Serene** (colour scheme) (*affective state*) **Quiet** (environment) (*affective objective description*)

The Stage 1 strategic options **Sensitivity** was re-expressed in Stage 2 by stakeholders requesting the design be considerate of their needs as neighbours and users. The Stage 3 evaluation of the building responds to this expectation with a multi-pronged evaluation littered with *affective* terms.

5. Discussion

The psychological typology and its associated *Affective Lexicon* employed in this paper provides a means of analysing the basis of the formations of assessments – expectations and evaluations – recorded in the language of Facilities Management. Both textual and verbal language forms have been encountered in this research. While the *Lexicon* used in this analysis provides a list of words that are considered in the literature to be emotion words Clore and his co-authors show that not all are emotions but belong to the range of types described in the psychological typology. This *Lexicon* is useful as it enables the psychological basis of assessments expressed in words to be revealed. Some are factually based as *objective descriptions*, some are subject-based internal evaluations and some are mentally formed.

This paper has concentrated on *affect* for three reasons. *Affect* has explanatory value for the warmth (positive and negative) in assessments of facilities. It is useful as an indicator of threats to well-being (related in part to the first point). And, it has a role in pre-emptively altering other mental evaluations. This research demonstrates the presence of *affect* in Facilities Management in the many words that are used in forming and describing assessments.

It is possible that *affect* may be present in all communication but for language that purports to be objective, as in the documentation of expectations, the presence of high levels of *affective* content, in excess of 30% in one stage of expectations and over 50% in the other stage, is remarkable. Thirdly, evaluations or reports of how those expectations will be met in the new facility also have almost 50% *affective* content. This is evidence of the importance of this psychological function in considering human's personal and subjective assessments.

Pure emotion (an *affective state*) was not found to be extensive (Table 3, Appendix 1), yet an emotional basis remains because of the *affective* content in the language. Of the *affective* content the majority are *affective external conditions*, both *objective descriptions* and *subjective evaluations*. The description component is, in Stages 1 and 2, consistent with the factual basis of the expressed expectations. In the Briefing evaluation-reporting stage the level of *affective subjective evaluation* rises in comparison with earlier stages.

Affect can be tracked across the briefing process where an *affective*-based expectation, **sensitivity** in this case, is expressed by both Council officers and stakeholders. Presenting the building design evaluations of how the building meets those expectations contain a range of *affectively*-based descriptions that are a direct response by the designers to the received expectations.

The endpoint in evaluations, to this point in the project, is that the Council officers responsible for delivering the project have assessed that these stakeholders are satisfied and happy (both *affective states*) with the design and the management processes employed thus far. It is this last point that most explicitly of the *affective* basis of human assessments of facilities. This goes towards answering the implied question in the *Introduction* as to why people use their perceptions and that is to achieve a personal *affective state* with regard to the facility.

The paper provides a more comprehensive understanding of the basis of expectations and evaluations, other than just labelling them subjective, through identifying their objective-subjective-psychological bases. These bases have been shown to exist on both sides of the expectation-evaluation gap. Where assessments are *objective descriptive* in form providing facts should support such assessments, and this research has found that many assessments are of this form. But *objective descriptions* may still have value as exemplified by something assessed as **important** (synonym of **unimportant** (*affective objective description*). Where assessments are subjective then the bridge will need to be individually relevant. To achieve this might require consideration of what an individual considers important (see above) or makes them happy (*affective state*). Where assessments are psychologically formed then processes to increase understanding (*cognition*) or **approval-of** (*affective-cognitive state*) facility proposals are likely to be typical of the bridge forms required.

6. Conclusions

This research originated in local government because it is susceptible to parochial politics which influences individual assessments. However, it is of interest generally to Facilities Management practice as meeting user or client expectations has been identified as being an important part of successful FM service. The discipline has struggled with addressing the gap between expectations and evaluations; be they of service delivery or the facility itself because attempts to bridge the gap have tended to rely on objective measures or on attempting to make measures objective. However, this paper has demonstrated the foundational basis of these expectation and evaluation assessments, particularly their psychological (*affective*) basis. Rather than labelling non-objective measures difficult or irrational and therefore opaque, this paper shows how they may be made visible. Such analysis reveals where assessments are factual, where they are subjective, where they are *affective*, or of some other psychological form; thereby beginning to illustrate the form that bridges may be required to have in order to span across the expectation-evaluation gap.

7. Future research

As this paper reports on facility provision up to the end of tender documentation it represents 'Work-in-progress.' Further research is required to examine assessments on facility completion. As this paper is concerned with facility provision processes consideration of the role of *affect* in other aspects of managing facilities is warranted, if *affect* is as fundamental to assessments as this research indicates.

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Appendix 1

Table 2: Prevalence of affective content in the expressions analysed

	Affective	Non-affective
Strategic options (n=43)	30.2%	69.8%
Brief building (n=53)	51.0%	44.4%
Meeting the brief (n=143)	48.9%	49.7%
Total (n=339)	**47.5%**	**49.8%**

Table 3:Affective conditions (emotion) in the data

	Affective conditions	Total Affective content
Strategic options (n=43)	2.3%	30.1%
Brief building (n=53)	5.3%	51.0%
Meeting the brief (n=143)	4.2%	48.9%
Total (n=339)	**4.4%**	**47.5%**

Table 4 Psychological conditions in the data

	Internal (psychological)		
	Affective	Non-affective	Total
Strategic options (n=43)	4.6%	27.9%	32.5%
Brief building (n=53)	18.3%	13.1%	31.4%
Meeting the brief (n=143)	6.3%	9.1%	15.4%
Total (n=339)	11.5%	12.7%	24.2%

Table 5 Break-up of objective and subjective in external conditions

	Affective external conditions				Total Non-affective external conditions
	Objective description	Subjective evaluation	Total	% of affective content	
Strategic options (n=43)	18.6%	7.0%	25.6%	84.8%	50.8%
Brief building (n=53)	28.1%	4.6%	32.7%	64.7%	31.4%
Meeting the brief (n=143)	14.7%	28.0%	42.7%	90.0%	40.%
Total (n=339)	**21.2%**	**14.7%**	**35.9%**	**75.6%**	**36.8%**

Unpacking Performance Measurements of Operational Building Assets – An Integrated Model.

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Abstract

Performance benchmarking and performance indicators are currently 'hot topics' in conversations within professional circles of both private and public sector organizations. The philosophy behind performance benchmarking is comparative analysis with the emphasis on analysis. The proper practice of performance measurement involves a careful analysis of processes and conscious selection of relevant performance indicators that are meaningful to the recipients who are then motivated to improving their processes and overall corporate performance.

This paper considers performance measurement of building assets as operating facilities. Operational buildings are at the same time, a physical asset, a functional facility, as well as a business resource. Literature on the subject suggests a wide range of views which tended to polarize towards either the measurement of the physical (technical) performance or the financial (cost) performance. Contemporary resource management supports the view that building assets are an essential resource just as human resource, technology; finance and knowledge are business resources needed to achieve corporate objectives. An integrated resource management approach views an optimum real estate or facility solution as one which is derived from consideration of all corporate resources to meet business needs. In this respect, the prime focus in measuring operational building performance must be viewed in the context of the relationship of building assets and their contributions to business outcomes. This is the premise upon which an integrated asset performance framework for performance of operational buildings has been developed. The content is process-focused in that it will unpack the components needed for performance monitoring of operational buildings and discuss some of the key issues that need to be resolved internally by an organization before the process of external benchmarking can be of value. Through a thorough literature review and brainstorming sessions with research collaborators, a framework for considering asset performance of operational buildings is developed and validated through two focused-group workshops in Hong Kong and Australia.

Keywords: Performance Measurements, Building Assets, Model.

1. Introduction

One of the key business performance issues for both business and government is the ability to leverage maximum performance from resources and drive effective management of resources for long term sustainability. Building facilities or assets are business resources in the same manner as technology, people and business capital. Increasingly, the dynamics of modern businesses demand solutions that optimize the utilisation of all these resources in the most effective manner. Hence the performance of building assets as a business resource is increasingly becoming a focus for management in both the private and public sectors.

Competitive pressures and tight economic conditions are driving the search for competitive advantage beyond a focus on costs and budgets alone. Business and government need to develop an informed view of what customers and end-users of services value and the level of performance expectations. These business drivers have a direct influence on the need to explore with a more searching attitude, more effective management of business resources, namely, the key resources supporting the business - people, property and technology [1]. The need and desire to monitor the performance of operational buildings as a class of assets deserves management attention because of a number of unique attributes:

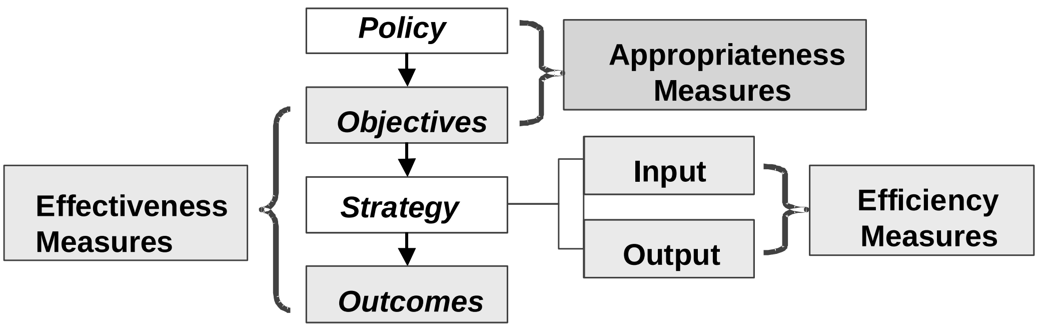
- the capital intensive nature of building assets (usually worth many millions of dollars which could potentially be applied more profitably elsewhere);
- their durable nature (often lasting up to 20-50 years or more);
- their relative inflexibility in responding to changes in business directions and technology;
- the significant accompanying stream of recurrent expenditure burden associated with maintaining and operating them at a desired service standard;
- the potential liabilities due to deterioration and depreciation over time;
- their impact on productivity and business performance; and
- their exposure to a wide range of legal requirements and risks.

The importance of performance measurement as a tool for effective management of such an important business resource is a key driver in the search for an effective performance measurement regime for building assets [2]. However, the practical implementation of a performance measurement regime that delivers the desired management outcomes efficiently and effectively is more problematic [3]. A wide range of methods and frameworks for performance measurement of building assets have been proposed [4]. They range from the detailed technical assessments of physical aspects of buildings to surveys of user satisfaction with the occupied space and quality of the internal environment. Despite this, there appears to be no commonly adopted framework for buildings against which performance measures of operational assets can be established to meet the particular needs of corporate management requirements and user expectations. This paper proposes an integrated framework for assessing building performance [5] and reports on the results of two validation workshops held in Hong Kong and Australia.

2. An Integrated Asset Performance Model

2.1 The Theory

The starting point of performance measurement is a conceptual model that can be applied as a framework for identifying and developing the necessary performance indicators that meet the objectives of any performance measurement effort. As a broad principle, performance measures can generally be divided into effectiveness measures, efficiency measures, and appropriateness measures (Figure 1).



Source: Adapted from Parker, W.C. (1993) *Performance Measurement in the Public Sector* and ANAO. *Best Practice Principles for Performance Information*. pp.8 [6]

Figure 1: Principles of a Performance Measurement System

Figure 1 highlights the need to clearly understand the purpose of performance measurement. Choosing the right measures for the right purpose is fundamental to any performance monitoring system.

2.2 The Need

The development of a conceptual framework for performance evaluation of operational building assets must recognise at least three important characteristics of buildings as a product, and as a business resource:

- Buildings have a much longer life than most other assets in business. A building represents a special class of durable assets requiring high initial capital investment and subsequent running costs and reinvestment – i.e. a regime of life cycle management is required to optimise its efficient operation;

- A building's value is represented by its effectiveness as a supporting resource in the overall value chain of an organisation's productive process. Its role as an enabling resource is increasingly seen as crucial in raising staff productivity – i.e. an integrated resource management approach incorporating the delivery of an enabling workplace environment must be acknowledged; and
- Buildings involve a number of stakeholders: owners, managers, service providers and users throughout their operational lives. Existing buildings are also being changed and renovated more often in response to new owners, organisational changes, and new occupant requirements – i.e. buildings as dynamic entities which must be managed proactively in order to respond to changing users' expectation and rapid technological development.

Evidence from the literature reviewed suggests that building performance monitoring is an amalgam of at least four aspects of facilities provision and their ongoing servicing as functional facilities:

- The appropriateness of the current asset base in meeting business objectives;
- The provision of a satisfactory working environment for occupants and customers;
- The minimisation of operating and maintenance costs by managing the condition of the existing facilities,
- The performance of the facilities as functional, operational assets supporting business processes.

In optimising the performance of building assets, an organisation must balance the interdependent and, often competing, outcomes of the above four aspects of asset performance in order to achieve their optimum service potential.

2.3 The EPFS Model

Taking the above constraints into consideration, Then and Tan [7, 3 & 5] proposed that asset performance indicators used by organisations from both the public and private sectors can be grouped under five broad facets of performance measures:

- **Economic measures -** The *Economic* facet of asset performance is concerned with decisions at a strategic level that optimises on value for money from property resources. Economic asset management requirements are governed by the need to relate physical facilities provision to longer-term business plans. The objective of measurement here is to ensure optimum resource allocation and affordable and economic provision of property resources in line with market offerings and business plans.

- **Functional measures -** The *Functional* facet of asset performance is concerned with management decisions that relate to the creation of the desired working environment in line with the preferred organisational culture and workplace standards. The objective of measurement here is to ensure continuous alignment of supply of appropriate functional space to anticipated service demands as far as possible. Fitness of purpose for property resource in meeting business requirements may be measured in terms of locational distribution, type, form and size of buildings.

- **Physical measures -** The *Physical* facet of asset performance is concerned with efficient and effective management of operational aspects of ongoing asset management. The objectives of measurement here are driven by the need to preserve asset value, ensure asset condition does not lead to unnecessary operational risks and liabilities, and to ensure occupancy costs are reasonable.

- **Service measures.-** The *Service* facet of asset performance is concerned with decisions and actions relating to quality perception by end users and quality of service delivery by service providers. The objective of measurement here is to ensure that the business context and organisational culture are appropriately reflected in aspects of service delivery and are aligned with core business requirements. Measures in this facet of asset performance are generally surrogate, often subjective indicators of performance derived from clients' and end users' perceptions of corporate facilities and support services.

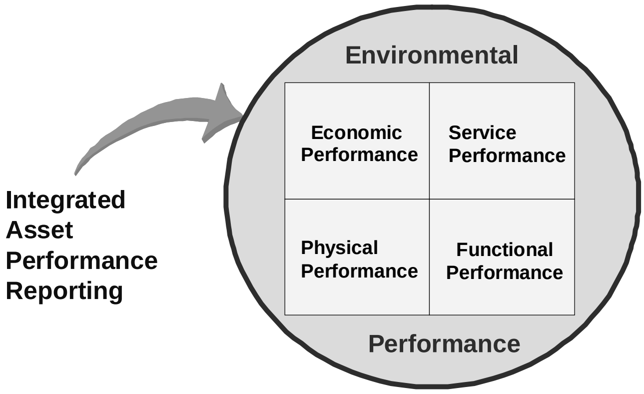


Figure 2: Integrated Asset Performance Reporting (Then & Tan, 2002)

- **Environmental measures -** The *Environmental* facet of asset performance is concerned with the role of building assets and their impact on facilities users, the community and the ecological environment. Measures in this facet are likely to involve monitoring against prescribed sustainability targets at project / state /national levels.

The premise taken is that any integrated asset performance reporting must incorporate these five facets of measurement in order to obtain a balanced view of the contribution of building assets as an operating resource, as illustrated in Figure 2. However, this paper only reports on four of the five facets of asset performance measurement. The Environment facet is the subject of another study.

The above five facets of performance measures form the cornerstones of an integrated asset performance concept that can be applied to:

- Fulfil specific stakeholder perspectives of asset performance;
- Guide selection of appropriate key performance indicators;
- Assist in defining data requirements for specified key performance indicators; and
- Provide a balanced view of asset performance.

Table 1 summarises the key management focus of the five facets of asset performance measures. Each facet of asset performance is governed by a different set of variables with its associated key performance indicators. The proposed model provides a structured approach for considering the many dimensions of built assets performance and critically reviewing the suitability of currently available measures.

Table 1: Asset performance facets and management focus

Performance Facets	Management focus	Focus of performance monitoring
Economic	Value for money	Efficiency in allocation of resources
Functional	Fit for purpose	Effectiveness in utilisation of resources
Physical	Operational risk and liability	Appropriateness in type and condition
Service	Customer satisfaction	User/client's Quality perception
Environmental	Workplace & environmental sustainability	Meeting prescribed targets at project / state / national levels

Then, S.S. & Tan, T.H. [5]

The necessity for a conceptual framework is supported by the need to explain, communicate and justify the need for data collection and analysis. A logical and consistent framework facilitates the process of focusing data collection on the asset performance parameters that are currently deficient or lacking from asset information systems.

Having a performance concept is only the first step in the implementation of an asset performance framework that is useful and cost-effective. There are a number of further steps which have to be navigated before full realization of a credible and sustainable asset performance measurement system [3]. Figure 3 illustrates the parameters within an organisational setting in which an asset performance measurement system must take into consideration. They are the factors that will influence the practice of asset performance management within an organizational setting. (modified from Then & Tan, [5]).

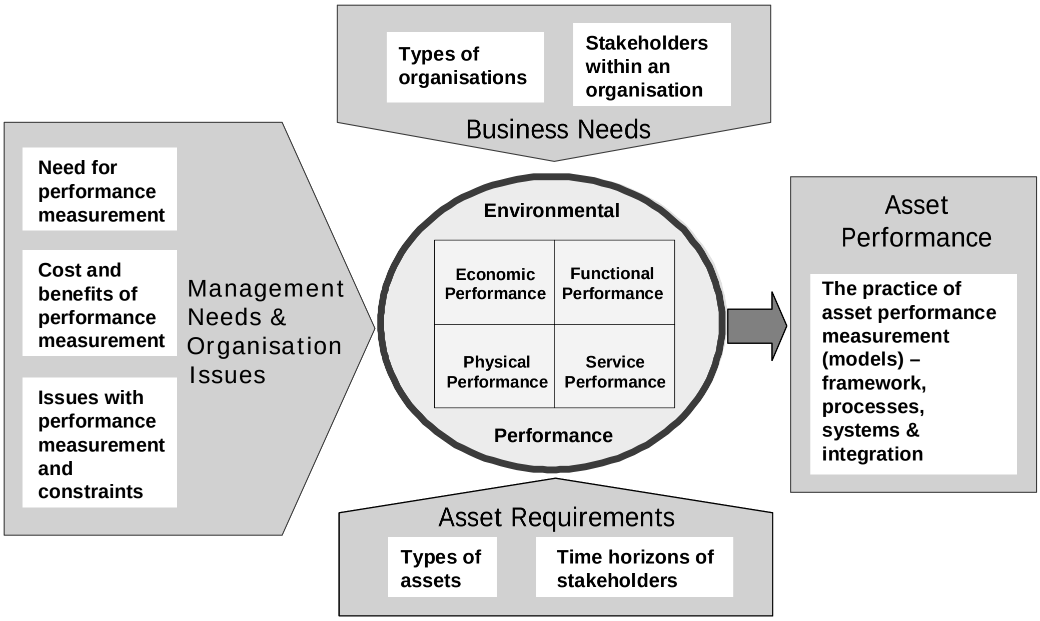


Figure 3: Factors influencing the Practice of Asset Performance Management

2.4 The EPFS Model – Variables and KPIs

Through a series of brainstorming sessions with research collaborators, it was decided that a structured approach is required to identify the appropriate key asset performance indicators. The alternative is a linear approach which has the potential disadvantages of being almost a random selection of measures or a selection that is technically driven by professional inclination.

The structured approach adopted comprised of a two-stage analysis. Stage one involved the identification of all possible variables associated with each of the four facets (i.e. Economic, Physical, Functional and Service performance). These are illustrated in Figure 4. Stage two involved identification of possible performance indicators that are measures of each of the variables identified. A total of 35 Asset Performance Variables and 95 Key Performance Indicators (KPIs) were selected for validation by two focus groups workshops held in Hong Kong (July 2004) and Brisbane (August 2004). The sample of the Hong Kong focus group (N=20) consisted of middle/senior managers with responsibilities for property and facilities services representing commercial buildings, airports, universities and banks. The sample of the Brisbane focus group (N=21) consisted of middle/senior managers with responsibilities for property and facilities services representing public sector facilities. In both locations, initial contacts were made via telephone and email, explaining the purpose of the workshop and who from the organisation should participate.

The deliberation of each validation workshop followed a structured format that comprised the following:

Session 1 – Introduction, background and purpose of workshop - 10-15 minutes,

Session 2 – Concept Validation:

a. EPFS Model Presentation by research collaborators – 30 minutes including questions,
b. Validation of EPFS Model by respondents via structured questionnaire – 30 minutes,
c. Validation of EPFS Variables via structured questionnaire – 30 minutes.

Session 3 – Practice Validation:

a. KPIs Presentation by research collaborators – 10 minutes including questions,
b. Validation of KPIs for each Variable via structured questionnaire – 60 minutes

Session 4 – Summary and Feedback.

In summary, both the workshops were well received by the participants who expressed keen interest in the outcomes of the research and analysis from the workshop questionnaires. A summary of the results of the research were provided as feedback to participants of the validation workshops.

3. Results of Analysis of Responses from Validation Workshops

3.1 Concept Validation of EPFS Model

The concept validation comprises a two-part analysis. Table 1 shows the results of the attributes validation of the combined sample of both sets of respondents from Hong Kong (N=20) and Australia (N=21). Respondents were requested to evaluate the EPFS model on five different attributes, each against a 5-point Likert scale. The model was highly rated against the attributes of *Completeness, Robustness, Importance* and *Practical Relevance,* scoring more than 4.0 on a 5-point Likert scale, with degrees of variation between 4.0 and 4.6.

Table1: Concept Evaluation of EPFS Model

Attributes	Mean	S.D.	Rank
Completeness – Degree of completeness in coverage of elements of asset performance	4.585	0.4988	1
Robustness – Degree of robustness in concept and practice of asset performance	4.439	0.5024	1
Usefulness – Degree of usefulness in making more informed decision on issues in asset performance	4.317	0.7563	1
Importance –Degree of importance in asset management practice.	4.317	0.7563	1
Practical Relevance –Degree of relevance in the practice of asset performance.	4.049	0.669	2

A pairwise analysis was also conducted to evaluate the respondents' opinions on the relative importance of the four different facets of asset performance: *Economic*, *Functional, Performance*, and *Service*. Six pair-wise importance questions with a nine-point linguistic scale were used [8 & 9].

The individual respondents' results on each individual pairwise question were aggregated using the geometric mean method before inputting into the necessary computation matrices. The final relative importance weightings of the four different facets of asset performance are shown in Table 2. No significant differences in the perceived importance of the four facets of the EPFS model were found for both groups of respondents in Hong Kong and Australia. A check on the consistency of responses was also performed to ensure the validity of the computed results. A consistency ratio of 0.0067 (<0.1) was obtained from the analyzed responses, which indicated that the responses given by all the respondents were quite consistent.

Table 2: Relative Importance Weightings of the four Asset Performance Facets

Asset Performance Facet	Relative Importance Weight
Economic	0.236
Physical	0.182
Functional	0.319
Service	0.262

3.2 Validation of Asset Performance Variables

For each of the asset performance facets, their potential asset performance variables were identified via a combination of literature review and brain storming sessions by the research collaborators. A total of thirty-five asset performance variables were identified for validation by respondents. A 5-point Likert scale type questions with '1' indicating *not relevant* and '5' indicating *very relevant*, for each of the asset performance variables was included in a questionnaire for the workshop respondents. Figure 4 illustrates the asset performance variables associated with each of the asset performance facets, together with mean relevant values and standard deviations. An asset variable is considered to be relevant if it has a mean value greater than 3.5.

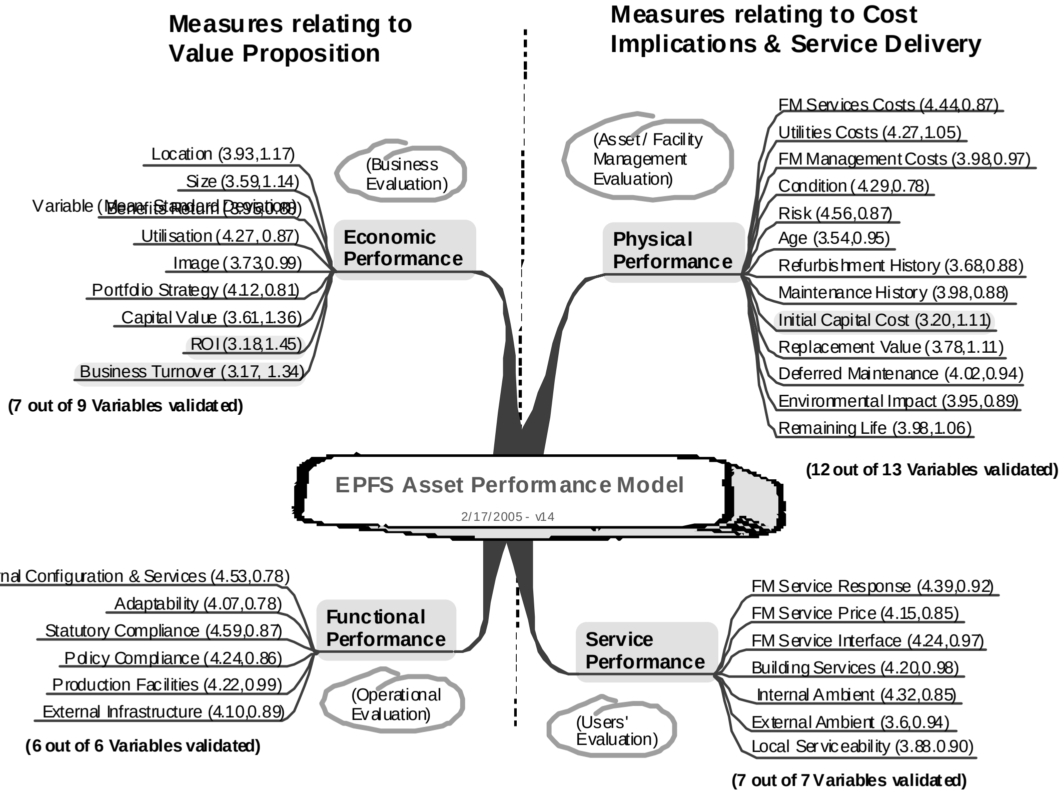


Figure 4: EPFS Model showing Asset Performance Facets and associated Variables

3.3 Validation of Asset Performance Indicators

For each of the asset performance facets, and their corresponding asset performance variables, a set of Key Performance Indicators (KPIs) were identified via literature review and brain storming sessions by the research collaborators. A total of 95 KPIs were selected and workshop respondents were requested to rate their relevance via a series of dichotomous questions with 'Yes' and 'No' options. An indicator is considered to be relevant if the percentage of respondents choosing 'Yes' is greater than 75%. A total of 68 KPIs were validated by the respondents. Figure 5 lists the selected KPIs against each asset performance variable and the corresponding asset performance facet. The sample size for the combined respondents from Hong Kong and Australia is 41 (i.e. N=41).

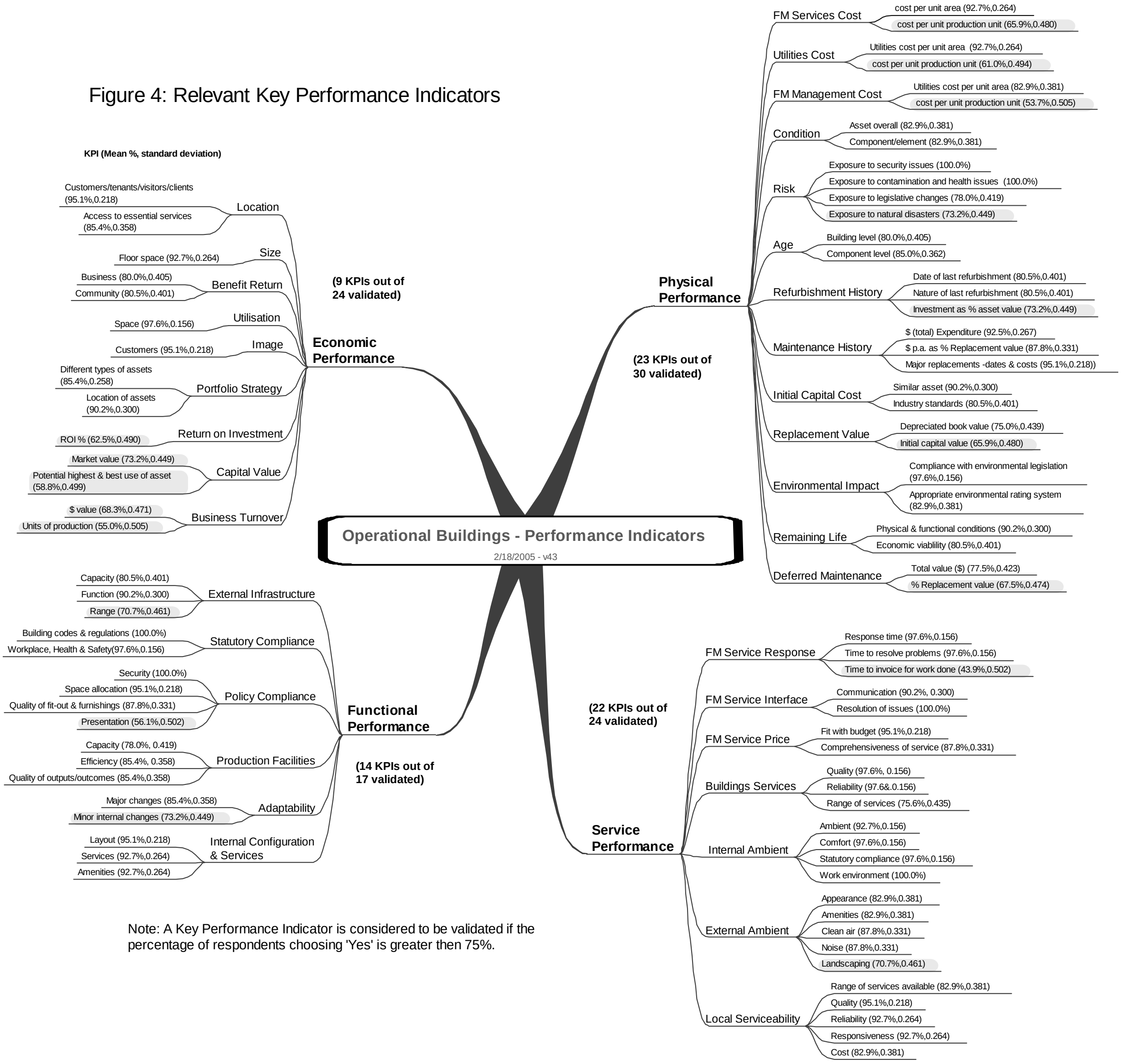


Figure 5: Relevant Key Performance Indicators against each Asset Performance Variable and associated Asset Performance Facet. (Note: Shaded KPIs <75%)

4. Conclusions

The quality of an asset performance measurement regime is subject to the proper definition, selection and organization of KPIs to provide relevant and reliable information for management decisions and actions. An unstructured and haphazard selection of KPIs is likely to lead to a waste of time and effort in data collection and incomplete or misleading performance information. This paper proposes a structured and logical framework for the development and selection of key performance measures. The EPFS Model provides a rationale and robust methodology for the organization of the KPIs selected and justification for the data requirement. Overall, the proposed EPFS model can be considered to be statistically validated relative to the sample of respondents in Hong Kong and Australia. The exercise has opened the doors for further development for practical use of the concepts underlying the evaluation of asset performance and the implementation of asset performance measurement towards best practice. It is anticipated that the EPFS Model will be further developed and refined through detailed case studies. The valuable assistance of the participants in the validation workshops in Hong Kong and Brisbane is gratefully acknowledged by the research collaborators.

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Seeing what you get -Balanced Communication for Owners

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Abstract

Part of a Nordic productivity study is reported here with focus on the owner and end-user and the correlation of price and quality of buildings. A product and a value model were tested on Swedish and Danish cases, which covered both new block of flats, renewal and laboratory. Differences in cost and reduction of deviations between cases are discussed. In the conclusion a structure is given for national or Nordic systems for benchmarking and key-figures and a number of supporting initiatives are presented.

Keywords: Building parts, quality, owner, end user, benchmarking and productivity.

1. Introduction

In 2004 five Nordic research institutes finished a joint study on productivity and benchmarking funded by Nordic Innovation. Through case studies, primarily on new blocks of flats, experiences and models for analysing productivity were discussed from two different angles – those of the construction company and the owner. The Swedish and Danish study is aimed at the owner and end-user, and shows how buildings of different locations, functions, sizes and standards can be compared.

1.1 The Nordic Productivity Studies

The Nordic Productivity Studies [1] was funded by Nordic Innovation (www.nordicinnovation.net), the former Nordic Industrial Foundation, according to the application submitted by the Norwegian Building Research Institute in the autumn of 2000 on behalf of five research institutes: Norwegian Building Research Institute (Norway), VTT Building and Transport (Finland), Icelandic Building Research Institute (Iceland), Danish Building Research Institute, (Denmark) and Swedish National Testing and Research Institute (Sweden).

The application included both building and infrastructure in the project. Early discussions showed that it was impossible to cover the whole area, and it was decided to base the research on case studies of housing and new blocks of flats. Another ambition was to discover common Nordic methods for data collection and comparison of cases based on the national experience. The first presentations of national cases outlined two opposite trends or two different target groups for the methods. One focused on construction companies, the production process on site and studies carried out on a comprehensive and detail level. The other focused on real estate from the end-user's, the building owner's and the customer's points of view, and the approach to the study had a broader and more general perspective. Each participant weighted these two tracks differently.

1.2 Activities in the Nordic countries

The building and construction sector can be divided into two supporting segments and three core businesses. The supported segments or the framework are public regulations (Regulation market) and research and education (Knowledge market). The core business is the three main segments along the value chain: The product market and the production industry; the construction market designing and constructing the building; and the real estate market where the owner, the developer and their advisers run the building as an envelope for the end-user for housing, work and institution (Figure 1).

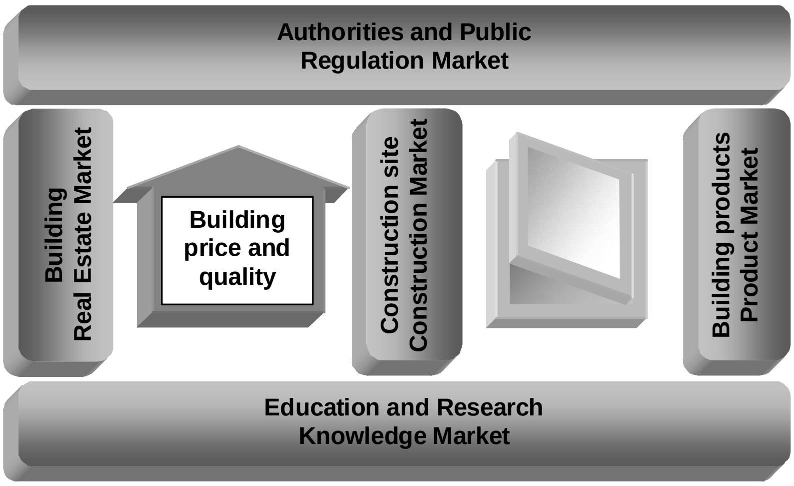

Figure 1: The building and construction (B&C) sector can be divided into five different markets and into two main types of 'products' – the building and building products.

Like in most industrial countries, the building and construction (B&C) in the Nordic countries is a major part of the GNP. In the European countries the B&C typically lies between 5 to 15 % depending on the market situation and on how the B&C sector is defined. The effectiveness of the B&C sector has an important influence on other sectors, the national economy and our well being and health. And the money invested and the capital tied up in real estate for housing, production and services are enormous.

Table 1: Construction companies (CC) in Nordic countries, 2002 (National statistics).

CC and part of total	Finland	Sweden	Norway	Denmark	Iceland
Turnover in CC in mill. EUR	139,700	312,340	190,091	156,590	8,952
Part of national total	14 %	7 %	10 %	5 %	7 %
Number of CC	224,847	842,000	429,910	297,706	8,184
Part of national total	13 %	7 %	9 %	9 %	8 %
Employees in CC in thousand	2,372	4,272	2,055	2,692	157
Part of national total	6 %	6 %	7 %	6 %	8 %

Table 2: Construction market (CM) in Nordic countries, 2002 (Euroconstruct).

CM in billion EUR			Finland	Sweden	Norway	Denmark	Iceland
Residential	New		3.6	2.2	3.3	3.0	0.4
	Renovation		3.2	4.3	3.7	3.2	
		Total	6.8	6.5	7.0	6.2	
Non-residential	New		5.3	2.2	4.3	4.0	0.3
	Renovation		3.4	4.6	3.7	2.6	
		Total	8.7	6.8	8.0	6.6	
Total			15.5	13.3	15.0	12.8	

1.3 Challenges for benchmarking productivity

The data collection and use of data seems to be similar in the Nordic countries, but the published data varies from one country to another depending of tradition. Statistical knowledge about the building and construction sector is in general based on national statistics. Most of the available data are macro economical, which means that the pictures given are rough and not very suitable for control and decision-making at company level. Nevertheless, the information is useful for the industry as general background. But when it comes to measuring productivity, the need for project level data is crucial.

The building processes in the five Nordic countries have a great deal of similarities. This should ease the benchmarking activities; if all other conditions of investigation were taken care of. Only few major research and development works have been carried out wit respect to measuring productivity, efficiency, value and quality. There is a need for productivity information in Nordic building and construction sectors on the micro level like in other sectors. To achieve similar statistical information about the B&C sector, the condition is to make project data available for common statistical studies. Till now this resource demanding challenge has not been taken. Instead there have been carried out local price- and costs studies to simply follow the change and 'explain' it in plain words.

2. Models for the Swedish and Danish study

The Swedish and Danish study focused the owner and his balanced communication with the end-user and the construction market from the early planning stage through the whole construction period into use and renewal. Based on experiences from different case studies a model was established for benchmarking the building more detailed than price per square metre. First level in the model is to make a comparison between buildings at different locations and building time – **the space model**. Second level is to analyse the deviations in price according to the different size, form, content and functions of the building – **the product model**. The third level is the correlation of differences in standard and quality including aesthetics and comfort – **the value model**. The fourth level is the differences between companies in industrialisation and level of changes, defects and claims – **the process model**. In the study focus was put on the product model and the value model.

2.1 The product model

In the product model the building is divided into different rooms, functions and building parts that are comparable across locations, type of building and the lifecycle of the building. The product model is a hierarchic of objects which build a bridge between real estate, the total building and the detail building product, and price and quality (the value model) can be connected to each object in the product model. Real estate is first divided into ‘The ground and site’ and ‘Building and rooms’. For each type of real estate a limited number of rooms and functions are defined (Table 3). In the next level the building is subdivided into ‘Building construction’, ‘Installation in building’, ‘Furnishing and equipment’ and ‘Common activities’. The last includes common activities for the building and construction process. VAT is separate in a single entry.

Table 3: The product model divides real estate in levels of objects in a hierarchic system, which builds a bright to building products and is visible for the end-user.

The real estate	**1. Ground and site**	**3. Building construction**
- Block of flats		
- Single family house	**2. Building and rooms**	**4. Installations in building**
- Office building	- Kitchen	
- Production	- Bathroom	**5. Furnishing and equipment**
- School	- Living room	
- Other examples	- Office	**6. Common activities**
	- Laboratory	
	- Other examples	**7. Value added tax (VAT)**

Each of three main building parts can further been divided into subparts (Table 4), and each of these can in turn be subdivided into different types if it is required. These subparts are directly related to the international classification systems for construction parts and materials, and real estate is related to the methodology in international statistic.

Table 4. Each main building part (here 3, 4 and 6) is divided into subparts, which can be common for all buildings and connected to the international classification systems.

3. Building construction	**4. Installations in building**	**6. Common activities**
- Foundation and ground floor	- Drain installation	- Construction site
- Exterior walls	- Water installation	- Design and planning
- Windows and exterior doors	- Heating installation	- Construction control
- Internal walls with doors	- Gas installation	- Project administration
- Story separations	- Ventilation	- Insurance of the project
- Roof and roof construction	- Electric installation	- Financing of the project
- Balcony	- Communication	- Other examples
- Other examples	- Other examples	

2.2 The value model

Building and constructions are normally benchmarked by comparing price per square metre gross area of the total building. In the value model price and quantity are connected in a unified price for each of the building parts and rooms described in the product model above. In addition the value model also describes the aesthetics, functions, standards and qualities as well as the delivery conditions. The main structure of the hierarchic value model is shown in Table 5.

Table 5. The main parameters in the value model. They can be divided into sup-parameters and connected to the actual objects in the product model.

Economy	Price, cost, profit and life cycle cost
Quantity	Unit, number, size, length, area and volume
Aesthetic	Design, form, texture, colour and appearance
Standard and quality	Function and applications of building and rooms
	Technical standards on constructions and installations
Delivery	Conditions on where, when and how each object is delivered

The first level is to measured price in relation to the quantity for each building, room and building parts in the product model. The unified price parameter can be calculated and used as a comparable key figure for benchmarking. Next level is to correct the unified price in relation to differences in technical standard, function, quality, aesthetics and delivery conditions. Measurable number, classification or a short description can be used to specify the value and explain the deviations between key figures or correct the key figures. An example of three typical rooms in housing is given in Table 6.

Table 6: Example of key figures and unit price on three types of rooms in new terrace houses for housing built in 1994 in Denmark [2].

Room	Standard and quality		Units	Unit price	Price
Habitable room	Paint ceiling and walls. Inner walls of 100 mm gas concrete. Floors of solid beech wood.	2,367	m^2 floor area	629	1.5 mill. DKK
Kitchen	Standard HTH kitchen. 10 m^2 floor area per kitchen.	400	m^2 floor area	1,765	0.7 mill. DKK
		40	Kitchens	17,647	
Bathroom	4 m^2 floor area per room. Tiles on the walls and quarry tiles on the floor. Normal standard of inventory.	160	m^2 floor area	6,272	1.0 mill. t DKK
		40	Bathrooms	25,089	

3. The Swedish case study

The Swedish case study included 32 different building projects of blocks of flats in Sweden. Twenty-seven of the projects came from a report from Boverket [3]. The cost data were given in applications for environmental subvention funding (‘Eko-bidrag’), and the data were collected before the buildings were finished. The projects therefore do not represent typical Swedish buildings. The next four projects came from the national committee report [4], and the last project was from the Svedala project [5]. The data from the last five projects were all final cost after the building was finished.

3.1 Distribution of different type of costs

Five of the projects were small student flats and one was located in the centre of Stockholm. All six differed in use, location and costs from the other 26 projects and were therefore removed from the case study. The rest of the projects were built in the period from 1998 to 2003, and a correction was made of the cost using 2002 as a reference. From statistical data it was found that the average price was increasing by 7 % per year. Each project was described by type of building, size, time and cost as given in Table 7.

Table 7: Type of data collected on each of the 26 Swedish cases.

- Type of building as name and community or town where the building is located.
- Size of building as number of flats, heated area (total gross area, BRA m^2) and useful area (gross area for flats excluding common area, BOA m^2).
- Time and date of starting and ending of building time.
- Production costs divided into 1) cost of site, 2) fees and taxes (not VAT), 3) financial costs, 4) building owner costs, 5) consulting costs, 6) contractor costs, 7) value added tax (VAT) and 8) total production costs.

The average size of flat in useful area for the 26 projects was calculated to be 72 m^2, and the smallest and largest flat were respectively 43 m^2 and 119 m^2. The average production cost per area was calculated to be 14,443 SEK/m^2, and the lowest and highest total cost were 9,658 SEK/m^2 and 20,139 SEK/m^{2,} respectively. The average production cost per flat was calculated to 1.05 mill. SEK per flat, and the lowest and highest total cost were 0.58 mill. SEK per flat and 2.01 mill. SEK per flat, respectively.

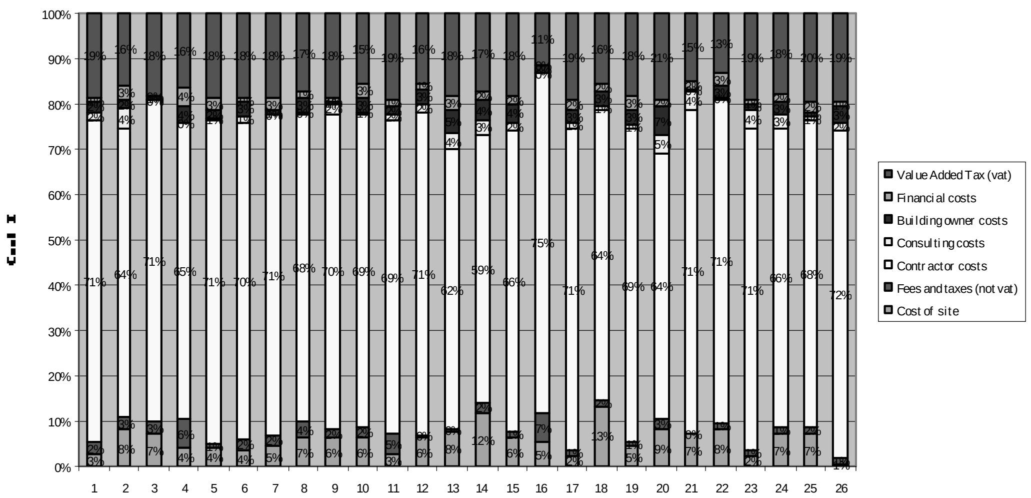

Figure 2: The distribution of seven different costs in % of the total cost for the 26 cases.

Table 8: Average value for the different costs.

Type of cost	***Cost in %***
1) Cost of site	6 %
2) Fees and taxes (not VAT)	2 %
3) Financial costs	2 %
4) Building owner costs	3 %
5) Consulting costs	2 %
6) Contractor costs	68 %
7) Value added tax (VAT)	17 %
8) Total production costs	100 %

As seen in Figure 2, the distribution of the different costs varies a lot from case to case. For instance, cost of site varies from 1 % to 13 %, fees and taxes from 0 % to 7 % and construction costs from 64 % to 75 %. The average value for the costs is in Table 8.

3.2 Benchmarking total costs

The next step in benchmarking building projects is to compare the total cost or the contractors cost per heated area (BRA). Normally a Salter diagram is used. Here (Figure 3) the columns are sorted in increasing cost per square meter heated area and the width of the column is the number of flats for the specific case. In Figure 3 it does not look like larger projects are cheaper, and we can see that the lowest price is 9,658 SEK/m^2. The Salter diagram can also use cost per flat and other values for the height of the columns and total cost as width of the column.

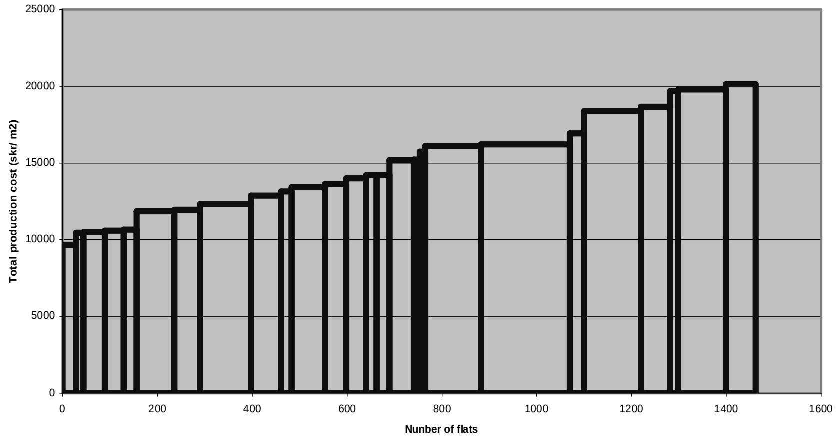

Figure 3: Salter diagram in increasing total costs in relation to number of flats.

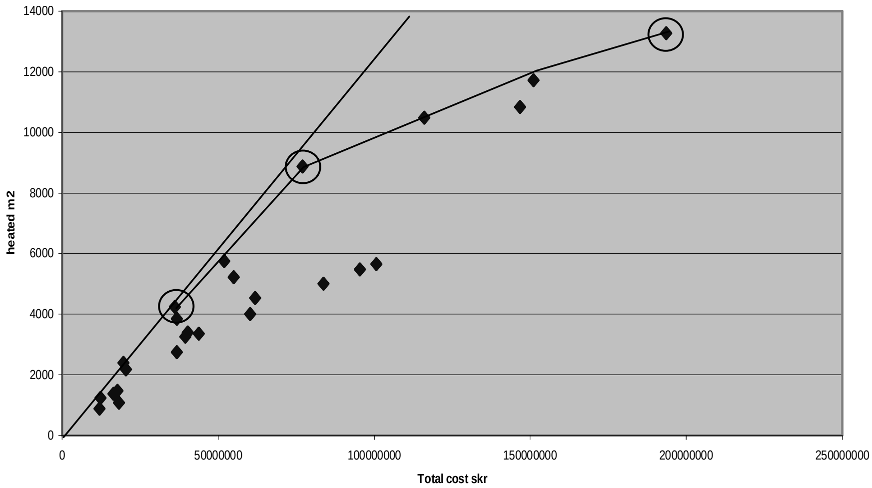

Figure :. Data Envelopment Analyse (DEA) for the 26 Swedish cases. Input is total cost in SEK and output is heated area, and the upper boundary is marking the best practice.

We can also use a Data Envelopment Analyse (DEA) [6] of the cases, where the production result (output) is analysed against the resources used (input), and the best practice is found as the upper boundary of the analysed cases. In the DEA of the 26 Swedish cases the output is the total heated area and the input is the total cost in SEK. As seen in figure 4 the upper curve is forming a boundary of best practice, and the following 3 cases (36.1 mill. SEK, 4,239 m^2), (77.0 mill. SEK, 8,873 m^2) and (193.5 mill. SEK, 13,269 m^2) are all representative of the best practice boundary.

4. The Danish case study

Experience gained from several studies shows that it is difficult to compare productivity between buildings because they differ in function and content. It is also evident that the variation in price per square metre indicates more than dissimilarity in productivity. Another cause is the difference in quality and value for the end-user, which moreover is difficult to measure and evaluate. When we compare buildings in cities with buildings in the country, we also find a marked influence from the location. In the Danish study the models are tested against these parameters on different type of cases in the search for a simple structure which fits international standards and the national opportunities.

4.1 Benchmarking against national statistic

Table 9: Benchmarking new terrace house against public statistics on housing. The benchmark is the median February 2003 and all costs include 25 % VAT.

Building parts and main accounts	Benchmark		Danish case 1		Comparison	
	Cost per gross area DKK/m^2	Part of total	Cost per gross area DKK/m^2	Part of total	Absolute Difference DKK/m^2	Benchmark index
Foundation	643	5,0 %	354	3,1 %	-290	55,0 %
External walls	1,231	9,6 %	1,262	11,0 %	30	102,5 %
Internal walls	1,260	9,8 %	830	9,8 %	-430	65,9 %
Ground and site	3,224	25,0 %	2,266	19,7 %	-958	70,3 %
Construction total	7,775	60,4%	6,898	59,9%	-877	88,7%
Common costs	1,874	14,6 %	2,345	20,4 %	466	124,8 %
Total costs	12,878	100 %	11,509	100 %	-1,369	89,4 %

Every six months the National Agency for Enterprise and Construction (Erhvervs- og Byggestyrelsen) publishes updated key figures on publicly supported housing on www.ebst.dk/-Boligmarked/Nøgletal. The statistics are divided into four different locations, five different functions and types of occupants and three different types of building. The cost per square metre gross area is distributed on 55 different accounts under the three main accounts: Ground and site costs, construction cost and common costs. Each of these 55 accounts is specified by lower quarter, median and upper quarter.

The first case is a study on a new terrace house and cost and gross area are compared with public statistical data on non-profit family housing in a municipality with a population below 50,000. Table 9 gives an example from the benchmarking of the three main accounts, the total cost and three different building parts. It is seen from the last column that the foundation is 55.0 % of the benchmark, the external walls are 102.5 % of benchmark, the ground and site cost is 70.3 % of the benchmark and the common cost is 124.8 % of the benchmark.

4.2 Comparing renewal of block of flats

The second case is a comparison of 88 different cases of renewal of a block of flats in Copenhagen. Data were collected on costs and units on 20 different building parts or common accounts. For each building part the type and renovation level was described and the average value for cost per unit and the corresponding standard deviation were calculated for similar types of renewal. For most building parts no change was found in cost over a period of 8 years and the standard deviation was as high as 25 % to 50 %. But renewal of windows showed another interesting profile.

Of the 88 cases 78 had had new windows installed and the total cost per installed window had decreased by 30 % from 1987 to 1994. In Table 10 the figures show a cost reduction from 624 DKK/m2 to 436 DKK/m2 gross areas. In the same period the standard deviation was reduced from 25 % to 17 %. It was concluded that the improved productivity was caused by industrialisation of both the window and assembly on site. Normally the cost figures are divided by the total gross area as shown in Table 10, but if we want to compare for instance the cost of renewal of the roof it is better to use the unit 'cost per m2 of covered roof area'. In Table 11 one project is benchmarked against the rest.

Table 10: Cost of new windows for three periods in the renewal of block of flats in Copenhagen. The costs are in July 1995 prices (DK index 138) without VAT.

Type of renewal	Cases		Cost per unit	Standard deviation
New windows 1987-90	27	31 %	624 DKK/m^2	25 %
New windows 1991-92	31	35 %	500 DKK/m^2	21 %
New windows 1993-94	20	23 %	436 DKK/m^2	17 %

Table 11: Four building parts in the project 'Oehlenschlægersgade 40' benchmarked against 88 renewal of the block of flats in Copenhagen (same index as table 10).

Building parts	**Benchmark**		**Oehlenschlæger..**	**Oehlen.. per benchmark**
	Cost per unit	St.dev	Cost per unit	
New bathroom	52,198 DKK/room	31 %	62,011 DKK/room	119 %
New kitchen	40,050 DKK/room	37 %	34,489 DKK/room	86 %
New heating system	423 DKK/m^2 gross	26 %	676 DKK/m^2 gross	160 %
New roof construction	2,759 DKK/m^2 roof	33 %	5,412 DKK/m^2 roof	196 %

4.3 University building and 3D visualisation

The third case is to determine key figures on different building parts on university buildings. The value model covering price, unit and level of standard is connected to the product model in 30 different building parts and accounts. Key figures are found on each building part and subparts as shown in Table 12 for external walls and windows.

In addition tests have been made on using a simple 3D visualisation in the communication in the early planning process with the end user. The 3D model was based on the collected key figures and colours showing different type and standard of rooms and building parts. Area, volume, total price and cost on the individual building parts were automatically calculated, and it was possible to replace building parts with other levels of quality and see directly the impact on the total price. The 3D visualisation has also been tested with success on new and renewal of block of flats **together** with the occupants.

Table 12. Key figures for different types (a to e) and the average price of external walls and windows on a new pharmaceutical university in Copenhagen built in 2002.

Standard and quality	**Units**		**Unit price**	**Price**
a) Walls and end walls of concrete covered with Swedish limestone.	1,045	m^2 facade	4,202	4.4 mill. DKK
b) Walls and end walls in concrete covered with blue subdued brick tiles.	845	m^2 facade	2,373	2.0 mill. DKK
c) Facade sections in steel and aluminium with sunscreens.	895	m^2 facade	4,828	4.3 mill. DKK
d) Walls and end walls in penthouse in steel with blue subdued brick tiles.	570	m^2 facade	4,909	2.8 mill. DKK
e) Walls in the basement in cast concrete on site and heat insulated.	900	m^2 walls	1,400	1.3 mill. DKK
Concrete walls, insulated and covered with bricks and tiles. Windows and glass sections of steel and aluminium.	4,255	m^2 facade	3,472	14.8 mill. DKK

5. Conclusions

The first rough benchmarking showed a deviation of 25 % to 50 %, and it could not be explained by differences in productivity alone. It was demonstrated that it was possible to split up the building in building parts and type of building parts, which could be compared between types of buildings. Connecting the individual object in the product model with values of cost, quantity, standard and quality the deviation could be reduced to more than 20 %. Based on the study it is recommended that a system should be improved if the deviation exceeds 25 % or smaller if the process is industrialised.

It is clear from the Nordic studies that it is difficult to introduce a common benchmarking system which covers the major part of the marked, different types of buildings and more countries and in addition can be accepted by the owner and construction companies. If an open system is preferred, it could be difficult to get information from contractors, and a system based on the owner must be preferred. Through the Nordic studies we formed a basis for future benchmarking systems which should have time and support to develop.

More international co-operation tailored to national options is proposed, and more research and innovation should emphasise: Simple 3D visualisation of the product and value model, methods for measuring standard and quality on different building parts, classification of type of rooms and building parts, which fits the purpose of the owner and end user, definition of units and key figures of rooms and building parts and network for exchanging experiences on benchmark system and use of key figures.

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Partnering with user participation – as a means of better functionality

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Abstract

The construction industry provides society with physical products not only in the form of finished buildings. It also provides the background for a number of basic living conditions and experiences in modern society such as forms of living, urban space, commercial centres, cultural activities, work places and transport facilities. This goes for new buildings as well as renovation of existing buildings.

Thus the building industry is a key factor in the efforts to create better living conditions. This was emphasised in a recent report to the EU regarding future research and development of building, cf. European Network for Construction Research (E-CORE) (1).

To accomplish this task it will be necessary for the enterprises of the building industry to develop new forms of planning which facilitate working on the basis of the interaction of the building with the activities that the building is to serve - during its whole service life. In this work users and their values could play a crucial role.

In Denmark a basis has been developed for improving collaboration – partnering – in a building project. This basis also opens for the possibility of involving the users far more constructively than has been the case up till now.

Keywords: Partnering, users, collaboration, service life

1 Clients create values

1.1 Overview

'Clients create values' is a development programme running for four years from 2002 – 2006 which at present includes 35 clients and experimental building projects organised in a network.

Elements that can improve collaboration are tested in each single building project. Examples of such elements are the use of workshops, elaboration of common objectives for the participants in the building project, common economic incentives, rules for conflict management, selection of participants/partners on the basis of competencies and budgeting based on open books. Altogether there are up to 15 elements that can be adjusted to fit the individual building project.

In 2004 the network submitted a proposal for a procedure for partnering based on reports on finalised experimental buildings projects (12). The proposal has received the general backing of the Danish building industry and the Government now demands that in every new building project the clients of public building projects should carefully consider whether partnering would be suitable for the project in question.

Guidelines have been elaborated that give directions and summarise the experimental results.

1.2 Industrial relevance

Based on the experimental building projects and the evaluations, the following picture of the advantages can be drawn:

- Collaboration promotes the possibilities of uniting architectural quality with buildability
- The close collaboration provides a better opportunity for involving the users and the values connected with the use of the building
- The transition between design and execution can be implemented with fewer misunderstandings, with more buildable project documents and more time to plan execution and cooperation on site
- Efficient control of economy/quality, survey of risks and improved conflict management are promoted for the whole process

2.What is partnering

2.1 Focus on dialogue

In practice partnering can be organised in a number of ways, but its core characteristics are reflected in the Danish *definition* which has found a general backing from clients and the organisations of the building industry:

”The concept of ’partnering’ is used to describe a form of collaboration in a building project and is based on dialogue, confidence, openness and with early involvement of all parties. The project is implemented with common objectives formulated by common activities and based on shared economic interests” (2) and (3).

In a preamble it is added: " Partnering should be established as a minimum between client, consultant and contractor".

The Danish Association of Construction Clients stresses "project optimisation in the programme and project phase with a view to create a better starting point for the building process and consequently a better product" as being a primary target (4).

2.2 Common characteristics and tools

In practice the definition provides the possibility of choosing between a number of procedures with some determining common characteristics such as:

- -An active client who decides to implement collaboration with partnering and who participates in a dialogue with selected enterprises about the design of the building project.
- -Dialogue and interplay where the contractors' knowledge is incorporated in the design. Economy, extent and quality are optimised in this open process between client, consulting and construction companies.
- -A partnering agreement, which includes a description of the common objectives of the parties, determines the framework for the collaboration and describes the tools that have been chosen for following up on the collaboration. This could be the establishment of a steering group, use of incentives and/or key figures, arrangement of workshops and methods for conflict management.

Partnering can therefore be described as a **number of tools**, which can be used to establish an individual procedure that matches the conditions and preferences in the individual project.

Here tools are mentioned in the form of keywords like: elaboration of *common values and objectives*, specification of the parties' *success criteria,* establishment of a common *steering group,* development of *competencies* before and during collaboration, agreements about the use of *incentives and incentive earnings,* follow-up through visible results and *benchmarking,* use of *open calculations* and books, arrangement of *workshops,* design with *participation* of construction companies, rules for *conflict management,* establishment of cooperation *on site* and keeping key persons.

The basis for the implementation of the building project is the traditionally used contractual agreements, cf. Section 6.

3. Focus on users' values

3.1 Value-based collaboration

Value-based collaboration has already for several years been used as a management form in business enterprises. The use of values in now spreading also to the building industry.

The client is the pivotal point when a building project should be developed that satisfies the users' needs. The client gets a new tool for planning by formulating the users' needs as the values credited with importance in the daily use of the building.

It is a tool that gives everyone involved in the building project – users as well as companies – better opportunities for communicating than traditional means like drawings or descriptions. Therefore dialogue and the formulation of values is the way ahead if new building projects are to be developed that provide higher satisfaction for all involved parties.

An issue for example might be whether it is open space , a good indoor climate, a low noise level, good daylight or other conditions that are the most important, and how they should be prioritised if it should become necessary – which it usually does. And during implementation of the project – is the most important value respect, punctual information, responsibility or other conditions, or all of them?

3.2 Different user groups

All relevant users should be involved. Examples are staff or persons with special skills. If the staff is not known, knowledge and experience from corresponding organisations can be obtained. Skilled persons can be persons with specialist knowledge of technical conditions. Finally users who only spend a short time in the building should be mentioned.

The organisation of user participation should be carefully considered in consultation with the users who could be represented by individuals or groups – and the framework of their work should be known.

The parties – not least the client of course – must beforehand consider well their own value base as well as wishes to the common values (5). Next they should jointly assess what benchmarks would be suitable for follow-up and for showing that the project is heading in the right direction. And finally, the desired level of ambition to be achieved.

The values should be understandable, meaningful and determining for decisions as well as social relations.

4. What competencies are needed?

4.1 The need for competencies

It is a necessary precondition for a successful collaboration in connection with partnering that the client and the enterprises possess basic technical and economic competencies. However, they should be applied in other ways in partnering, for example by letting designers work in a more interrelated way with the construction companies than is the case in traditional collaboration.

Moreover, collaboration in connection with partnering implies that a need exists for special supplementary competencies that can support and promote the collaboration. Especially for the tools previously mentioned under the characteristics of partnering (6).

At the same time it is crucial for a successful collaboration that the entire group functions well as a team intent on implementing the actual building project as “Project Partnering Inc.”

4.2 Pivotal role of the client

The client should begin by assessing whether the client organisation possesses the competencies necessary for its daily operation in relation to collaboration in openness and confidence. It is also important that the organisation has an overview of which methods and tools that can promote collaboration in partnering.

The client can choose to supplement his organisation with a consultant with knowledge of the practical organising of partnering and tools for supporting the collaboration.

A distinction could be made between three forms of competencies in connection with partnering: *managerial, technical and personal*. The client – and the client’s consultants – are in a central position to ensure that the competencies necessary for the implementation of the building project are available.

4.3 Selection of partners

Through the selection of design and construction companies, the client can see to it that persons with basic competencies participate. And later *during collaboration,* for example in a dialogue with the partners and in workshops, the client can initiate a survey on a more detailed level to establish the need for competencies and establish agreements about development or incorporation of lacking competencies, if it is considered necessary.

In practice the client can at first *select* the companies through prequalification that are considered suitable due to their general – basic – references. At the same time the client signals that the tender documents will include a closer description of the need for competencies at the implementation of the actual building project.

When *awarding* the design task and subsequently the task of executing the construction work, or both at the same time, the client could as a next step let the description of persons participating in the collaboration, which has been prepared by the companies, form part of the assessment to select the companies.

In a large building project, the sub-criterion for organisation was given the weight 20 % and based on the CVs of key persons. It was further subdivided into design, execution and sub-contractors, each with 1/3 and marked on a scale from 0 to 13.

5.Establishing a collaboration

5.1 Tendering at partnering

It is important that the client as a **first step** at an early stage - before or during the brief – assesses whether partnering will be a suitable procedure for the actual project. By early assessment it will be possible to choose between several procedures, in particular between early or late partnering, cf. below.

The client's assessments must be made within the framework conditions in force. The most important for public clients are the EU Directive on Tendering and the Danish Act on Tendering. In 2004 the EU adopted two new directives. The Danish Act on Tendering is expected to be revised in 2005 (7) and (8).

Overall these changes support the possibility of partnering and specify some conditions in connection with tendering like the use of sub-criteria.

5.2 Early or late partnering?

When the client has chosen partnering as the form of collaboration for a building project, the **next step** is to find a partner. The basis for the tender (selection of partner(s)) could be the brief**,** outline proposal or scheme design.

A distinction can be made between early involvement of the construction companies, meaning before the scheme design (”early partnering”) or later for example after the client has had an outline proposal prepared (“late partnering”).

The client should decide which form is the more suitable for the individual building project. At the outset “early” cannot be considered better than “late”.

At present early partnering is used in approximately 60 % of building projects and late partnering in approximately 40 % according to one survey (9). For early partnering, design and build contractors are typically used, while for late partnering for example smain contractors or trade contractors are used.

In the background material for the tender the client must describe the demands and wishes to the collaboration, for example in the form of a proposal for a partnering agreement which includes requirements to competencies, cf. above. The client can choose to request the tenderers to provide proposals for items in the agreement and let the proposals be incorporated in the assessment of the tenders and thereby the award.

The **third step** is to enter into a partnering agreement, which will remain in force until tender and contract – and as a rule form part of the contract.

6 Partnering agreement

6.1 Traditional contractual arrangments

It is normal practice – and it is recommended – that collaboration aims to use one of the traditional contractual arrangements. There are no examples of joint and several liability that also include consultants/contractors. But it can be included in a partnering agreement that a later contract should include specific provisions for the cooperation with consultants in connection with the implementation of the contract like for example contact to the client.

The partnering agreement can involve the users and as a minimum it contains a description of how the users’ knowledge and values should be included in the planning.

It is recommended that the partnering agreement runs until handover. And it should for example include the socalled lean production, which could involve foreman and workers in the collaboration.

The agreement will also need to include an agreement on how to manage possible conflicts. Known methods are a bottom-up process for solving disputes, dispute Review Board, pre-emptive conflict management and mediation.

6.2 Main items of the agreement

Main items of the partnering agreement will typically be: a description of the *parties* and *the purpose* of the collaboration, a concrete outline of the collaboration with the establishment of some *success criteria*, the framework for the *economy* and the time schedule, a *programme* for the future building project with an indication of targets for quality and the environment, the *basis* for the collaboration and the contribution to the partnering of the parties, conflict management and possibilities for *cancelling* the agreement, the basis for the contract(s) and possible contracts concerning incentives/incentive earnings (10).

There are different views of where the partnering agreements should be placed in relation to the actual contracts regarding its implementation. One way is first to make the agreement with a description of the conditions for its implementation. This is a conditional agreement, which will be continued in a contract if the conditions are met. Another way is to make the agreement in connection with the contract. The agreement should decide the possibilities and conditions for termination of the collaboration.

7. Implemention of the collaboration

7.1 How to create a good collaboration?

The basis for the implementation of collaboration is the partnering agreement, which has decided the objectives and framework for the collaboration together with the tools will be used by the parties.

The collaboration can be organised in different ways with regard to the structure of the brief, time schedule for workshops, user participation, utilisation of competencies and establishment of groups.

7.2 Steering group

Large building projects should establish a steering group with the overall responsibility that the objectives of the agreement are met with regard to the design of the future building project as well as for daily collaboration. The steering group could be seen as the ‘board’ of ‘Project Partnering Inc.’

The steering group should be a non-executive body and strike a balance between being a controlling and an inspiring factor for the collaboration. The steering group should function during the whole building project.

In the previous section on ‘Characteristics of partnering’, keywords are used to indicate a number of tools that can be used to support the collaboration. It should be assessed from one project to the next, which of the tools are relevant just as the actual wording should be agreed between the parties.

7.3 Tools in practice

The three tools most frequently used are: *elaboration of common objectives, shared economic interests and common activities*, including workshops. These are used in nine our of ten building projects (3) and (9).

Common objectives have been agreed in approximately 85 % of building projects. In less than 10 % of the projects, they were agreed before consultants and contractors became involved.

In 65 % of building projects consultant and contractors are paid a fixed price. Here *incentives* are used such as keeping the time schedule, budget. In just under 70 % of the agreements with contractors and approximately half of the agrements with consultants this is used.

Regarding *conflict management* the most applied method is the bottom-up process for solving disputes/level model, where disputes as a starting point should be solved at the ‘lowest possible’ level. This method is used for seven out of ten building projects.

A particular characteristic of the partnering agreement is that it involves collaboration during execution on site. There are several experimental building projects, for example where lean construction is applied and a number of common activities are carried out as well, not least regarding safety and health.

7.4 Utilising experiences

During the whole course of the collaboration – from the client’s considerations concerning the future building project via the tender to handover – the parties will be gaining experience. Most will be continuously utilised, but a status after finalisation of the building project can make the experiences of a more general nature stand out and can therefore benefit the partners’ participation in a future building project – with new parties.

This could be effected through a workshop – maybe several for large projects – arranged when the building project has become operational, for example three months later (11).

8. Conclusions

The building industry provides the background for a number of basic living conditions and experiences in modern society. The interaction of a building with its users and their values during its whole service life will therefore become increasingly important in coming years.

In order to accomplish this task, it is necessary to develop forms of collaboration that ensure that the users' values are incorporated and their knowledge utilised. A first step has been taken in Denmark with a new form of collaboration called partnering.

A number of tools or elements are being developed, but already a picture of this form of collaboration is taking shape. The most important characteristics are an active client, dialogue and interplay between the parties of the building project and a partnering agreement including objectives for the collaboration, elements to ensure the collaboration and the contribution of the parties to the collaboration.

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The Role of the Client in Best Value Procurement

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Abstract

Clients with focus on end-users expect buildings to facilitate their business objectives. The increasing importance of end-users satisfaction creates the need for a performance based approach as to allow the management on end-results, and to provide a language they can understand. With such an approach the match between the clients' business objectives and the buildings will be facilitated and as a consequence buildings can be treated as factors of business rather than a capital asset only. A holistic approach is helpful in monitoring and assessing the output during all phases of the process, from project initiation to use and facility management.

In many countries all over the world programmes are ongoing with the aim for more or less radical reforms in the building and construction sector, and procurement appears to be a key factor for improvement in delivering added value for clients. A significant future trend is recognised in an explicite role of clients and focus on end-users, and consequently, the need for best value procurement of the built asset as a whole is apparent. This, in turn, calls for innovation through more co-operation, because such an approach drives prime attention towards whole building performance rather than to technology of parts and components. In doing so, managing added value should be addressed explicitely in the interrelation of product, process, and people.

When best value procurement is the leading ambition, the price-quality ratio of the output should be in the selection criteria rather than the focus on lowest price of tender only. Clients should approach industry in a way that stimulate the vendors to launch their best professional performers for the job required, which in turn requires a professional outsourcing client attitude. This will stimulate the development of instruments that allow monitoring and improvement of the output over the lifetime of a building, and consequently enhance building and construction process innovation.

Key-words: Clients, End-users, Best value procurement, Performance-based approach, Reform

1. Introduction

The need for reform in building and construction is recognised worldwide. In particular the public client is a very significant client for construction and it is therefore essential that public sector procurement practices reflect the objectives of reform. If the large public principals, and also the large private principals set the trend, the rest will follow. These large organisations have buying power, and they can take advantage of that.

From the clients perspective, a building can provide substantial return on the investment, but to enhance this return the building must be seen as an asset that exists to facilitate the client's objectives with focus on end-users. Value is a crucial concept in the procurement of a building and is difficult to measure in numbers, means or technical solutions. A performance-based approach may be helpful because it focuses on end results with regard to the asset rather than on means with regard to the technology of parts and components.

It is crucial to identify the stakeholderships of the construction client in its diversity from real estate investors to property managers and principals on to 'once-in-a-lifetime-clients', in order to treat the role of 'the client' in best value procurement. Value creation should be enhanced for both client and industry, and a shared vision from the perspectives of clients, industry, and government may be developed on added value of building and construction. Such a vision can be implemented through the development of a method of performance based briefing, that can explicitely be related to best value procurement.

2. Procurement is key-factor for improvement

Procurement practices are of crucial significance in building and construction reform. Traditionally, procurement has been based on price. The introduction of 'non-price' factors and best value procurement in the award of contracts and of 'value for money' criteria and innovative approaches to tendering can have major impact. The central place of procurement in reform leads naturally to much greater focus on client requirements and on the need to raise the capabilities of construction clients [1].

2.1 An international trend

The Proceedings of the 1st Revaluing Construction Conference in Manchester UK 2003 [7] revealed an international trend towards more value and quality driven competition, and also public client leadership in procurement. Meanwhile interesting construction reform initiatives are found abroad, many of those taking a lead with the UK Rethinking Construction Programme. A Dutch programme 'PSIBouw' (Process and System Innovation in Building and Construction), designed to encourage innovation in the construction industry, is currently mobilising all those involved within the building and construction sector [1]. This research programme has secured substantial funding of approximately € 43 million from both government and industry for a 4 year period.

The first PSIBouw project was an inventory of international reforms in construction, including a study tour to Australia, Denmark, Finland, Hong Kong, Norway and Singapore. In total, around 75 meetings were held with key individuals and representative bodies in these countries, and the lessons learned revealed major findings on the fields of procurement, the role of the clients with end-user focus, and the need for an integrated approach in building and construction.

The international trend shows a consistent move towards non-price and value-based procurement, away from focusing on lowest price only. Examples from Australia and Norway revealed the advantage of qualifying and selecting parties on their competence in co-operation in high performance teams. Life cycle costing is an item of topical interest in the Norwegian building industry, and indirectly it does enhance value-based procurement, in particular because LCC assessment is now mandatory for all public buildings, following a Norwegian standard.

2.2 Best value and non-price factors

New procurement processes were developed in Australia, Hong Kong, and Singapore, with greater emphasis on past performances and introducing best value and non-price factors in tender evaluations [1].

The National Museum of Australia was constructed using alliancing principles in which risks were shared between the client and the supply side, and a trust and no-blame culture was promoted. Major infrastructure projects, like the extension of the Hong Kong Kowloon Canton Raiway Corporation have similarly been constructed under partnering arrangements, allowing close liaisons between demand and supply sides.

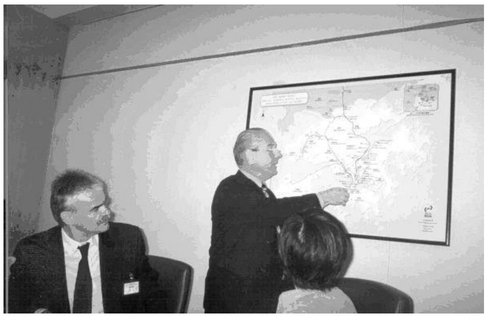

Figure 1: National Museum of Australia (left) and CEO Hong Kong KCRC Ian Thoms

The role of public procurement is evident in all countries visited, and public sector procurement practices reflect the objectives of reform. Some programmes, for example in New South Wales Australia, focused on the power of public sector procurement in developing a Code of Practice and a Code of Tendering, both applied in pre-qualification procedures.

The Department of Public Works in Queensland Australia improved the value for money effect by introducing rigorous pre-qualification standards, and new forms of contracts like non-adversarial, alliancing, and keeping regular dialogue with the industry. Leading private sector clients in Hong Kong and Singapore have adopted the same procurement principles as the public sector and so reinforced the reform process.

3. Clients with end-user focus

A significant future trend is the increasing role of clients with end-user focus.

The increasing importance of end-users satisfaction creates the need for a performance-based approach as to allow the management on end-results, and to provide a language they can understand. With such an approach the match between the clients' business objectives and the buildings will be facilitated and as a consequence buildings can be treated as factors of business rather than a capital asset only. There are good practices with the ASTM functional and serviceability requirements developed in Canada [5].

3.1 Construction Client Associations

In order to empower the position of the client in enhancing innovative construction practice effectively, clients should be properly identified and organised. In doing so a diversity of client systems related to types of clients, such as end-users, 'once-in-a-lifetime' clients, and professional clients may be distinguished. The so called 'intermediate' client – operating between client/end-user and industry – is particularly characteristic for the work of government building agencies. There are successful practices with Construction Client Associations in Denmark, Sweden, and Australia, all focusing on end-users, principals, and owners [2].

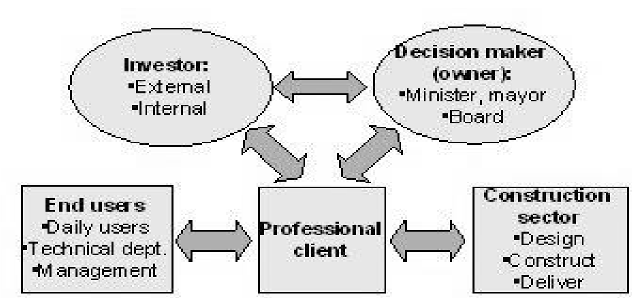

Figure 2: Professional client relationships – CEO Danish Construction Client Association Henrik Bang

These client associations, enhancing professionalism in clients, are currently developing as powerful driving forces for reform within the sector. Representing the majority of large construction clients, they have a sound impact on the development of improvements of products, process and services of the building and construction sector.

Demand driven research programmes are pushed by these client associations in Sweden, while acting as a Change Agent in construction, and professionalising their members, funded by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning [6].

The associations membership ranges from every leading institutional investor, pension fund, property trust to private investors and developers, and as such, these associations can strongly influence the process of policymaking in procurement.

3.2 Client briefing methods

In order to facilitate understanding in client briefing methods, it is proposed to agree on an appropriate context that covers all the stages in the sequence of a building and construction process. This context is determined by three characteristics (Figure 1):

Firstly, briefing is manifest in all phases of the building and construction process, from project initiation on to use and facility management. It is in the nature of this process that alterations do occur all the way from the start to the hand-over of the built asset. Secondly, core competences affecting demand, production, and use and facility management are distinguished, and in doing so, domains of competences can be determined accordingly. For instance, demand competences are manifest within the phases of project initiation and definition, while product competences generally are in the phases of design, design documents, and construction on site, followed by the phases and competences of use/facility management.Thirdly, there is this continuous process of learning and ever improving expertise by effectuating the benefits from the process'life cycle, and as a matter of fact, the briefing process should start with the evaluation of the existing housing situation.

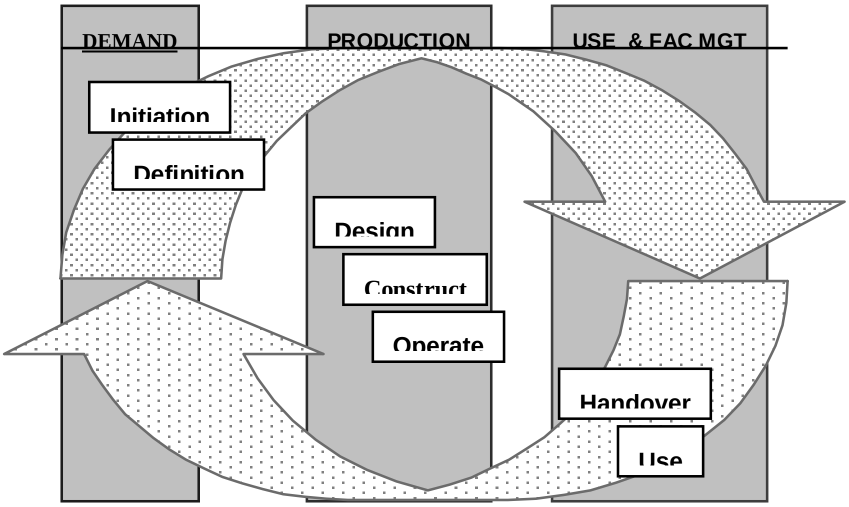

Figure 3: An appropriate context for the briefing process

Within this context new ways of briefing are developed using modelling techniques that provide client-organisation based functional outputspecifications, and can link these systematically to service quality, facility management, design, and costs [8]. The brief is converted into a digital model, that provide performance criteria in terms of organisational goals and ambitions, functional requirements, performance specifications, verification methods, and references of acceptable solutions. The method is applied in practice in behalf of the Dutch Treasury in the Hague, a € 200 million project, to be tendered in a concession form of PPP (Figure 4):

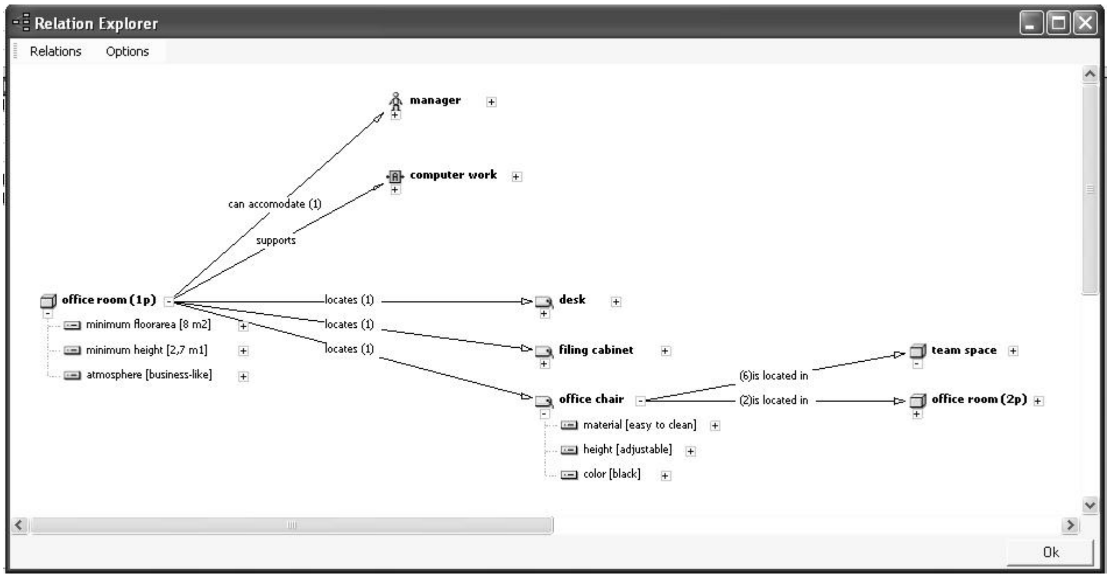

Figure 4: Modelling outputspecifications with focus on service quality [8]

3.3 Client assessment methods

Within the building and construction process from design on to hand-over, specific moments of risk for client dissatisfaction occur at the moments of transaction from one phase to the next one. One reason for failing causes is that the quality control traditionally relies on explicite assessment of technology of building parts and components (which not directly affect the clients expectations of performance), while the quality of the built asset as a whole (which indeed affects the client's organisational, economic and functional performance expectations) is being assessed 'pretty implicitely' beyond proper control, causing client dissatisfaction [9].

As a consequence, moments of risk are determined when matching assessment between the client brief and design, between design and construction documents, between desgn documents and construction on site, and finally, between hand-over and use within the so called domain of production competences, mentioned in 3.2 'Client briefing models'.

Each match is characterised by a different way of expressing (total) building asset performance, and in the traditional design and construction process it is definitely difficult to make sure that the constructed result matches the performance, that was initially expected by the client [3].

There are two causes to this situation: the lack of a systematic approach to the subject as an end result during the design stage, and the absence of a defined party that should be responsible for its implementation [10].

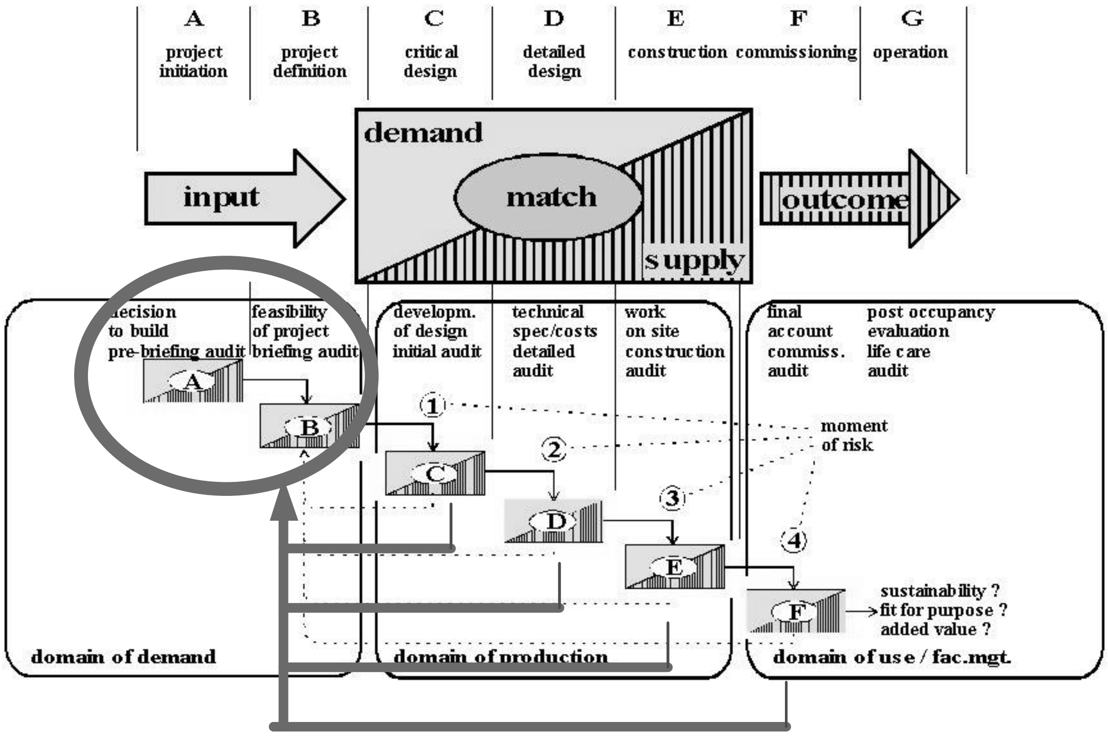

Figure 5: The moments of risk and assessment of brief [3, 4]

Therefore it is suggested to monitor and assess at all transaction moments between the phases during the process of production, and to focus all assessment, no matter in which phase, with reference to the initial perfomances required in the client brief rather than to the results of the result of the previous phase (Figure 5). The application of such a process enhances a systematic approach to the end result during the process of production, and it also stimulates the commissioning of a defined entity responsible for its implementation.

4. Best value procurement

Central to best value procurement is successfully recruiting the high performers in the design and construction industry. This way of recruiting is based on the Information Management Theory (IMT), followed by the Performance Information Procurement System (PIPS) and the application of the Six Sigma Model in construction [11].

If clients keep selecting vendors on lowest price only, these will consequently launch their cheap in-hired low performers, as to keep in business. But if clients act as ‘professional outsourcing clients’and select on inventiveness, creativity and sustainability, vendors will launch their high performers in order to keep in business.

4.1 Procurement strategies

From the viewpoint of the construction client, it may be obvious that procurement strategies start considering which services and activities to keep and to outsource when purchasing a built asset. Central to the clients'view may be the value for the end-user, and how to purchase this in best value procurement:

Clients may want value for money from their buildings by achieving a clear focus on meeting business needs; their immediate priorities are to reduce capital costs and improve the quality of the built asset by the right procurement strategy. A longer term, and more important, issue is reducing running costs and improving the standard of eventual existing buildings.

A specific trend is that best value procurement seems to be the leading ambition [2], and the price-quality ratio should be in the selection rather than the focus on lowest initial price only, because it will enhance product- and process innovation, and stimulate the development of instruments that allow monitoring and improvement of the output over the lifetime of a built asset.

These considerations are often part of the internal conditions of a projectspecific situation, and of course the market situation plays a substantial role in terms of external conditions prior to decide upon procurement strategies.

4.2 Decision support models

Recently in 2004, a projectspecific procurement decision support model was developed in co-operation between the Delft University and the Government Building Agency in the Netherlands, based on ex-post experiences and evaluation and ex-ante analysis of a few governmental real estate projects, i.e. the so called 'PAIR'model, which stand for Projectspecifieke Afweging Inkoop Rijkshuisvesting [12].

The model generates projectspecific recommendations for the strategy of procurement, as a result of an input of 11 procurement themes with an average of three procurement options each, considered within a projectspecific context of given project criteria (time, budget, organisation, quality expectations etc.), internal conditions (such as parties involved within the project, type and ambition of client in terms of involvement in the

project) and external conditions (such as the context of the project in terms of site, European regulations, market conditions etc.)

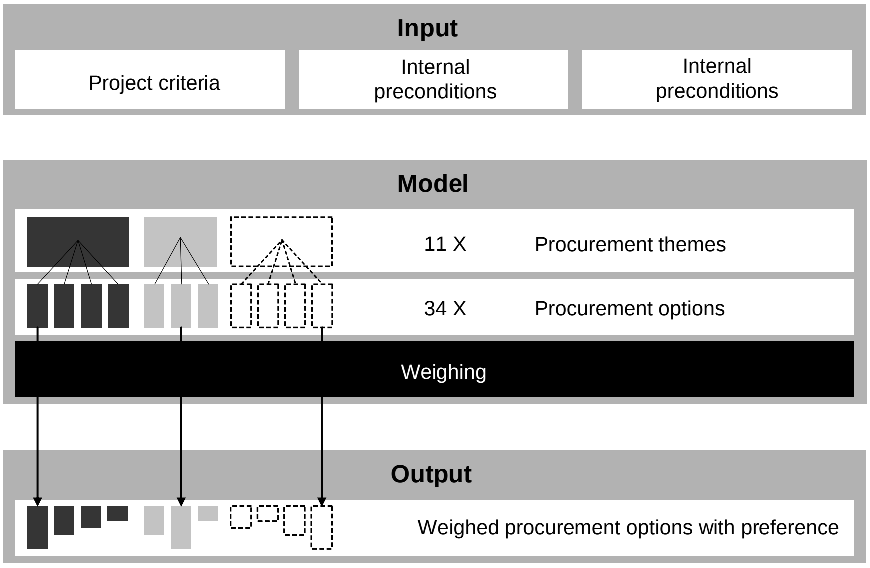

Figure 6: The 'PAIR-model', procurement decision support system [12]

The output of this PAIR model consists of weighting the projectspecifically selected procurement options within the 11 procurement themes, such as the division of project or process, number of vendors to co-op with, contractual relation between principal and vendor, design responsibility, risks and finance responsibility, criterion of selection, demand requirements, system of contracting, and reward sytem. In theory, there are 165.886 combinations of procurement options and strategies [12].

5. Conclusions

On the demand side, clients need to develop a greater ability to express the requirements and aspirations of end-users and society in a consistent and comprehensive way. Furthermore, they need to bring these requirements to the market in a way that challenges the supply side to produce solutions that maximise value for clients, while launching their high performers. Finally clients need to be able to assess the added value of different solutions. These changes may be summed up as the development of professionalism in clients. The creation of Construction Client Associations may promote more professional procurement. In some countries, existing organisations can form such associations, and in other countries, a special new initiative may be required.Training and educational courses can support dissemination of best practices and experience developed through these associations.

Procurement practices are of crucial significance in reform of the building and construction sector. They are the meeting point of demand and supply, through which the supply side responds dynamically to the demands of the clients side. Therefore, procurement processes need to encourage behaviour that is in line with aims for industry, placing emphasis on quality, performance, value, and the development of learning opportunities. To do so, however, implies a move away from traditional selection methods based on 'lowest price'. International experiences can provide a guide to the ways in which new procurement mechanisms may be introduced while maintaining proper safeguards against malpractice. Registration systems, together with transparent and accountable pre-qualification procedures, may play a major role in these new procurement processes.

Last but not least, there appears to be a large need for demand-driven research practices in order to support client professionality and innovation in best value procurement. A network of international knowledge, and experts, should be initiated on these fields, eventually by a starting initiative of the Dutch Knowledge Centre for Process Innovation in Building and Construction, CRC for Construction Innovation in Australia, Salford University, The Centre for Total Building Performance in Singapore, and VTT Finland.

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Perceived Quality in Buildings: Human Factors in Global Quality Approach

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Abstract

To control integrated and complex dimension of building quality, we need to expand references to further cultural and scientific field, able to integrate technical aspects with human factors, in both design and management activities. Turning to human factors methodologies and tools we would be allowed to design and control global quality of building environment. The rising of user's expectancies level, the role of user's characteristics, and the variability joined to the specialization of activities, make so that an effective quality control must include human factors and user interaction with buildings.

Keywords: End users, Needs, User centred design

1. Introduction: a different approach to building quality

1.1 Overview

Observing the development of the idea of buildings quality from 70s up today, we notice that its control is moving towards systems more and more complex. In fact, we overcome a concept of quality as correspondence between performance and requirements applied of technical elements and we get to a new and more complex quality idea including the whole of building global performances, evaluated in relation to end user's needs. Users do tasks characterized by a rising involvedness, determining use models of architectural spaces even more specialized and composite, with a consequent increasing final quality demand. We can state that building quality is evolving in terms of all-in quality, even if user's expectancies are not clearly expressed in relation to the end-users perceptions. All that means that users expectations are referred to the human life-quality offered by buildings, also including behavioral, organizational and psycho-perceptive factors in human-building- interaction. At the present, quality aims coming from each specific field lead apparently to broken down and diverging visions, also because of the high-specialized competences and functions involved in building process.

1.2 The human centred approach

The new quality vision that comes out from most recent standards directions emphasizes the role of user's satisfaction. This point of view implies that quality has to be considered not only as a correspondence between building's performances to a set of predetermined requirements, but it results from the rate of motivation, support and gratification –in one word: satisfaction- felt using a specific system. Then, quality is anymore referable to the sum of all single performance, but is clearly related to the whole of combined effects of a system on its users, and so the quality has to be reported to the users' perception of system use. Moreover, the increasing relevance attributed to users' expectancies and their physical and behavioral characteristics, the variability of preferences and ways in everyday activities make so that an effective control of perceived quality should be based on human factors consideration and their interaction with built environment.

Methodologies and tools coming from human centred design provide an useful contribution to the built environment global quality. This approach, that requires competencies in ergonomics science, is able to improve all these field, today controlled separately one from the other, best fitting the current idea of building quality. In fact, ergonomics highlights relations among technical, organizational and human factors affecting -implicitly and/or explicitly- buildings' planning, design, fulfilment, fruition and management. User centred methodology founds on some basic steps:

- all users profiles definitions
- users goals in relation to each user's category
- task analysis of each user's activity
- definition of use requirements of product/service
- conversion of use requirements in technical requirements and details.

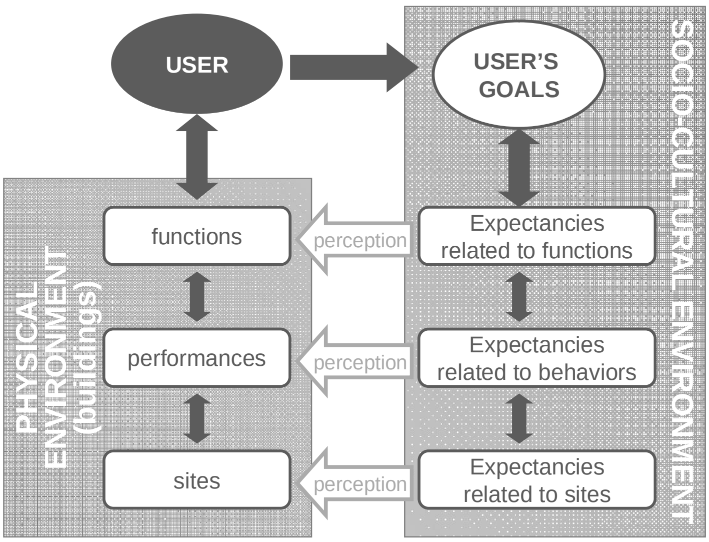

Figure 1: Relationships among context of use elements in built environment quality perception.

Operative techniques of User Centered Design produce many iterative processes in which users participate directly or indirectly to the design through simulations, interviews, observations, etc.

In fact, the user centered approach focuses the quality assessment on relationships establishing between systems and its users; then, following the user centered approach, quality means quality in use, appraisable through the usability measurements. Effectiveness, efficiency and satisfaction [1] are the three parameters allowing to define and measure specific markers for each observed system. Moreover, the wide variability of users' goals and characteristics make so that the usability or quality in use is not an intrinsic and absolute performance of a system, but it will depend on its different modality of fruition or, in other words, on the context of use [1].

2. Users and building quality

According the proposed approach the building quality topic is rather matching the building usability, that means the quality of interaction humans-built environment. The complexity characterizing a built system implies many multiple interaction levels, from a "sensorial" sphere to an "intentional" one, that is connected to goals pursued by users in buildings fruition. Following points are going to specify logical steps resulting from the user centred methodology applied to architectural design.

2.1 Users

First step is the definition of users' profiles. Already from this early stage, users' categories shall be defined considering the global use of buildings, therefore needs and expectancies of all users groups come up from the analyse of direct and indirect users, specific users (adults, older peoples, children, …), occasional users (cleaning or maintenance personnel, visitors, …). Each user's category is characterized by different physical and cognitive abilities or variables socio-cultural background that have to be taken into account when deciding building's technical requirements or evaluating its performances. For instance, we could think to diverse colours perception in aged peoples, to balance or orienting difficulties in children and elderly peoples but also to the potential way finding and orienting weakness in casual users of an environment [2].

2.2 Users' goals

Goals are explicitable according many different keys and can result differentiate and specifically oriented for each users' profile. For instance, we could look at some "cross goals", generally related to built environment; this kind of goals can be: adequate safety and security conditions, climate protection, pleasantness of spaces, environmental comfort, maintainability, etc. All these needs often are already considered in a traditional design process, but in a user centred approach they are enriched with many immaterial values and meanings. As an example we can quote the safety: user is not fully satisfied if its safety conditions are objectively assured by buildings, rather, in its opinion, the safety performance will result actually guaranteed only if user will feel safe and protected in a space.

Then, the quality control focused on users and their emotional and sensorial sphere affects perceived quality level and leads to rates diverging from a traditional evaluation measurement. Textures, orienting, wayfinding, identity of a places, are just some of aspects touching the actual level of user expectancies satisfaction that means the quality value according users [3].

About needs related to function hosted in a building, the user centred approach supplies some methodological tools able to highlight existing link between space-functional layout and organizational systems: in fact relationships and interferences among functions or actions and time, flows, rules can be clearly detected thanks to UCD. Therefore, a building quality meant as match between activities and living model is strongly supported by the UCD methodology that, on the other hand, stress the link existing between dwelling quality and the ability of building to support and make easier users activities (with reference to many useful concepts such as affordance, constraint lack, …).

2.3 Activities and tasks

From the task analysis of all users' categories is possible to understand their expectancies towards physical environment, strongly connected to their preferences and mode in tasks execution. In fact, through a tasks' analysis, a basic tool in usability field, designers can define what users need in term of actions or cognitive processes, to achieve their goals when interacting with any system. The task analysis consists in a task breakdown structure, where all actions are logically and hierarchically related to each other. Moreover, some specific analysis such as link or layout analysis, allow to observe modality of tasks carrying out and makes designers able to specify all that factors in built environment so that favour or hinder users life condition as regards to their goals [5, 6].

2.4 Use requirements

All data gathered and analysed in previous steps supply information on those characteristics of built environment necessary to satisfy the whole of users expectancies. So, general and technical requirements definition step become a strategic phase in building process because in this moment, and on the basis of all prior analysis, the quality process can assure that all actual users demands -and not those ones supposed by designers- will be transposed in technical requirements and building's detail characteristics. In fact, technical standards, designer experience, conventions and cultural references give to designers a "hybrid" model of users' needs, hardly controllable without a specifically user oriented design methodology [4].

3. Managing the building process through perceived quality

Building process in characterized by a plurality of involved actors, expressing different and, sometimes, opposite quality aims. In fact, in end use phase, quality perceived by end user coincides with the life quality offered by buildings, but during design and construction stages the different subjects have priority, and then quality aims, very dissimilar to end users' ones. This intersection and overlapping of dissimilar quality aims, joined to the process complexity, make so that each subject recourses to its own control criteria and evaluation system, from which could come contrasting solutions. Instead, the user centred approach, thanks to the possibility to recognize and relate needs and expectancies according more point of view, is an useful support to an unitary management of building process.

It seems now useful to report how ergonomic competencies support each process actor, contributing to improve the all-in process efficiency. First of all we have to consider that user oriented analysis is very helpful for customers, because they can better express they needs and, then, formulate in a more appropriate and not generic way their requests; moreover, if customer is not end user (i.e. the case of public buildings) UCD techniques allow the respect of end user "mental model" [7] for spaces rather a stereotyped or unreal one. Finally, the initial clarity about needs makes plain and effective the communications among customers and other involved subjects, reducing mistakes and ongoing modifications.

On the other hand, designers' activities are facilitated by UCD because this approach supplies a well defined set of needs and requirements. This condition allows to save time and resources carrying out planning activities, thanks to the high quality and quantity of input data; besides the user centred approach focuses the choice among many spatial or technical alternatives respecting not only management aspects (durability, maintainability, …) but also fruition ones (layout flexibility, psychological effect of environment, …).

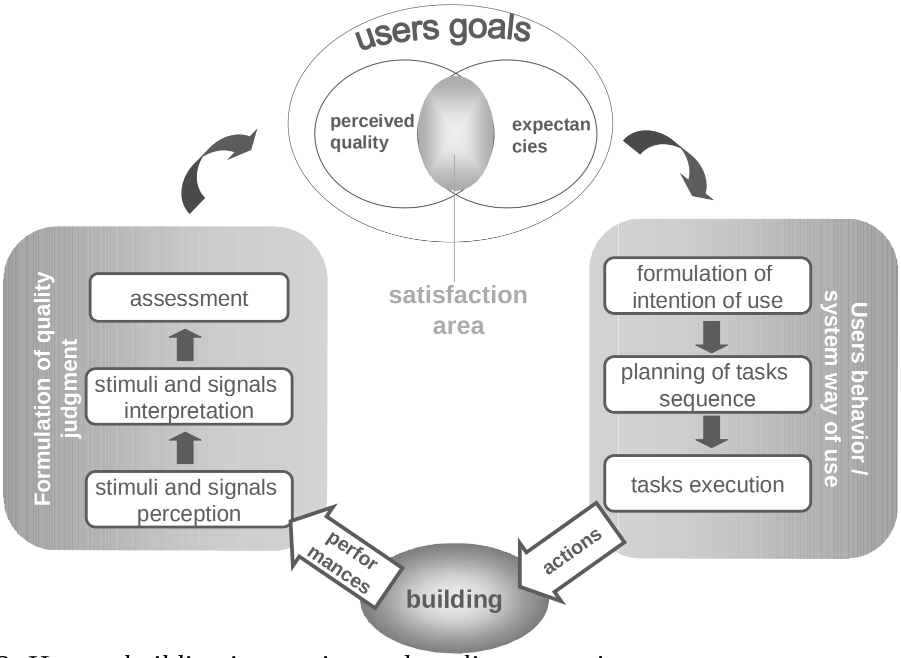

Figure 2: Human-building interaction and quality perception

4. Conclusions

Contribution of ergonomics to each step or function in building process allows to highlight relationships between human, technical and organizational aspects establishing in planning and design of buildings, benefiting and managing of real estate. Therefore, basing the building quality control on quality or qualities actually perceived by users is a strategy to improve building quality in either its aspects: formal and substantial ones. In fact, to the increase of efficiency levels in building process can correspond also a life quality improvement for direct and indirect users. This approach is tangent the TQM one and offers operative tools and theoretical references able to control the relations setting among many variables of building system and, finally, allowing to reach a global quality.

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How Do PCTs Measure Users Experience?

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Abstract

The National Health Service (NHS) sector in the UK will be undergoing dramatic changes in the next few years. This is due in part to changing service user requirements and the implementation of the Agenda for Change programme, Department of Health [1]. Many healthcare providers within the NHS have lost track of the true needs of their service users and are trapped in outdated views of what healthcare delivery is all about. This is evidenced in the report by Nigel Crisp (NHS chief executive) in October 2002, published by the Department of Health. This report [2] clearly stated that the NHS needs to refocus its management efforts, engage with patients, staff and the public and build momentum to manage for excellence.

This paper describes a post-graduate research study into service user experience as a key element of service excellence in Primary Care Trusts (PCTs) in the NHS; and the notion of user-based 'healthscape'. The study employed the use of literature review and a case study approach to the collation of data. Analysis was primarily undertaken through content analysis.

The paper presents the results of a thorough examination of the impressions of the users through the entire healthcare experience identified through a survey of healthcare users in the case study trust, and a review of the current measurement techniques in the PCTs, which suggest that the current system is not representative of user experience. It also suggests how to move forward in capturing and measuring user experience in the pursuit of service excellence.

Keywords: Service User Experience; Healthscape; Service Excellence.

1. Introduction

1.2 Aims and Objectives

The aim of this paper is to investigate the construct of user experience as an integral part of service excellence within the NHS healthscape. Its objectives are to recognise and scrutinise the methodologies currently used within PCTs in the NHS to measure user experience in pursuit of service excellence; and recommend more effective ways of measuring user experience.

1.2 Overview

It is not so clearly accepted within the NHS that user experience is a critical indicator reflecting the strength of healthcare delivery. This is evident in the findings of Hwang *et al*, [3] who attributes these deficiencies to the lack of clarity and consistency in understanding the determinants of user approval. While service excellence assessments based on user experience is a useful guide, it is important to continue to strive for improvements which reflect the changing marketplace. Against this backdrop it is important to continue to reassess user experience.

Given the central role that service users can play in the excellence of any organisation in general and in the NHS in particular it is, perhaps, surprising that the current state of knowledge regarding user experience seems somewhat limited. There is no consensus on the definition of user experience or what it constitutes. This ambiguity also extends to its role within the evaluation process of service excellence, conceptualised as driven by the user experience. Users do form impressions about a range of service excellence constructs and these impressions vary across service providers and individual users. What is not clear is the extent to which these impressions are used, if at all, once the service has been experienced in a user's evaluation of service excellence.

2. User Experience

2.1 What is User Experience?

User experience is a journey through which the user senses the core benefits and the pleasurable performance of the service transaction in finding and approaching the service, interacting with other users in the right environment and departing from it, Abusaid & Alexander [4]. This definition implies that in order for users to experience the service, they have to go through a multifaceted cycle. This cycle starts from the moment that the user seeks to approach the service, makes a connection through the telephone/ internet and goes all the way through until the service is actually experienced and the user leaves the 'servicescape'.

According to the Oxford Advanced Learners` Dictionary [5] a user is "*a person or thing that uses something*", whilst experience is "*an event or activity that affects some one in some way: enjoyable, exciting, unusual or unforgettable*". Experiences can be classified into four categories, Pine II and Gilmore [6]:

Entertaining experience - a passive way to engage a customer and attract an audience of shoppers.

Educational experience - where the customer immerses in the event developing before him. This type of experience requires an active participation of the customer in the event to increase his knowledge and skill.

Escapist experience - where the customer is completely immersed and actively involved in shaping the experience.

Aesthetic experience - where the customer is immersed in an environment but has little or no effect on it, leaving it untouched.

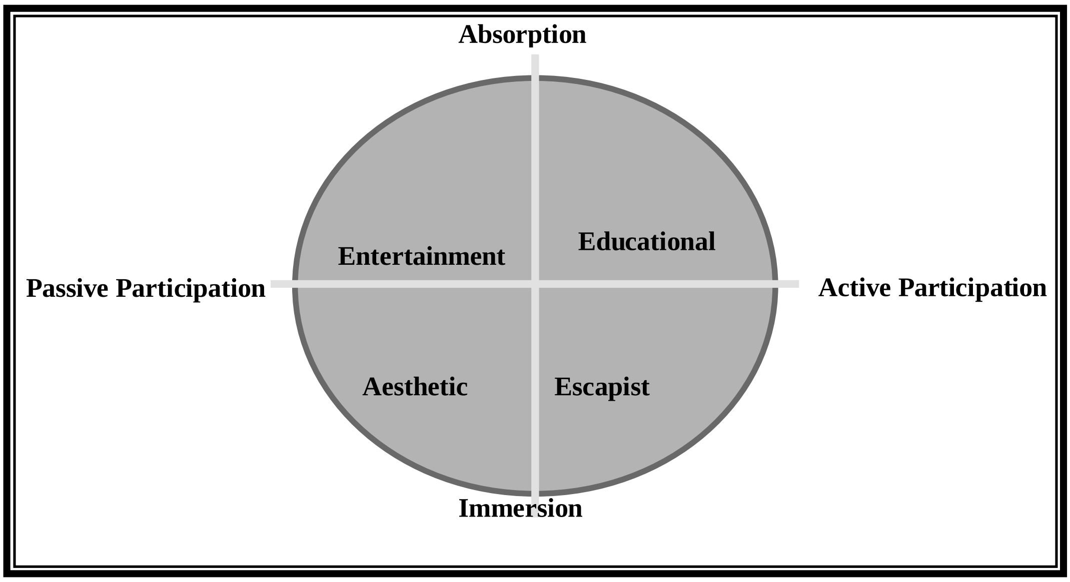

Figure 1: The Experience Realms, Pine II and Gilmore [6]

The escapist experience is the type of experience that should be promoted and encouraged within the NHS, because the user is completely absorbed and actively caught up in influencing the experience.

2.2 How does user experience differ from user satisfaction?

The NHS in the UK has witnessed the introduction of numerous quality initiatives over the past decade; driven by the realisation that patients were not satisfied with the health care delivery, and the necessity for the NHS to restructure in order to better respond to patient demands. The general consensus is that there are too many initiatives following on one after the other. Furthermore, most of these initiatives seem to lack two important features: relationship with each other, and the integration of all aspects of the organisation's activities into focused action on continuous improvement and customer desires, Stahr [7].

User satisfaction within the UK NHS tends to be based on assumptions about users needs from the NHS perspective. Many approaches deployed to measure user satisfaction neglected the impact that the process of healthcare delivery may have on the user satisfaction.

User experience differs from satisfaction in the sense that it allows the user’s own interpretations to be discovered. Research to date has been regarded by the researchers as questionable because it does not address issues that directly matter to the service users. Furthermore, the researchers identified that most established methods of measuring user experience are within the secondary healthcare sector, which has a different role to PCTs. In addition, the current measurement system imposes issues that are of concern from an NHS perspective, and not from the user perspective. It was felt that this was an issue of concern for the rigour and reliability of the measurement of user experience in the primary care setting.

2.3 Factors affecting user experience

Rowley [8], [9] applies factors that contribute to the user experience to liberalities and museums. These factors are: speed of service delivery, convenience, age, choice, life style, discounting, value adding, customer service, technology and quality (see table1 for further details).

Table 1: Users impressions of PCT healthscape

Healthcare Provider		Impressions of Service	Impressions of Environment
GP	Single-handed ( )		
	Group practice ( )		
Practice Nurse	Single handed ( )		
	Group practice ( )		
Dentist's Practice	NHS ( )		
	Private ( )		
Chemist's Shop	Incorporated ( )		
	Not incorporated( )		
Opticians	NHS ( )		
	Private ( )		
PCT: physiotherapy, paediatric, district nurse, out of hour, health visitor, minor surgeries, speech & language therapy, contraceptives			

Some of these factors may not necessarily apply to all organisations, although there are some common factors that can be shared. For example, discounting can be more influential in profit driven organisations and less so in non profit making organisations such as the NHS. Furthermore, organisations that rely on handcraft work would be less affected by technology than those that are heavily dependent on technology such as the NHS.

2.4 A typical user experience within NHS PCT

As mentioned earlier**,** user experience is defined as a journey, which implies that the user will go through a sequential process. This process varies depending on the type of healthcare provider and also on circumstances that a user may experience (see figure 2). The user journey according to the figure 2 consists of eight sequential phases. Phase one is initial contact where the user will contact the doctor's surgery either by telephone or the Internet to make an appointment. The second phase involves the way in which the user will get there for the appointment. This involves physical appearance at the surgery either by walking or by any other means of transport. The third phase is entering the surgery. This phase is important because the user starts to engage with both the service and the 'servicescape' at this point.

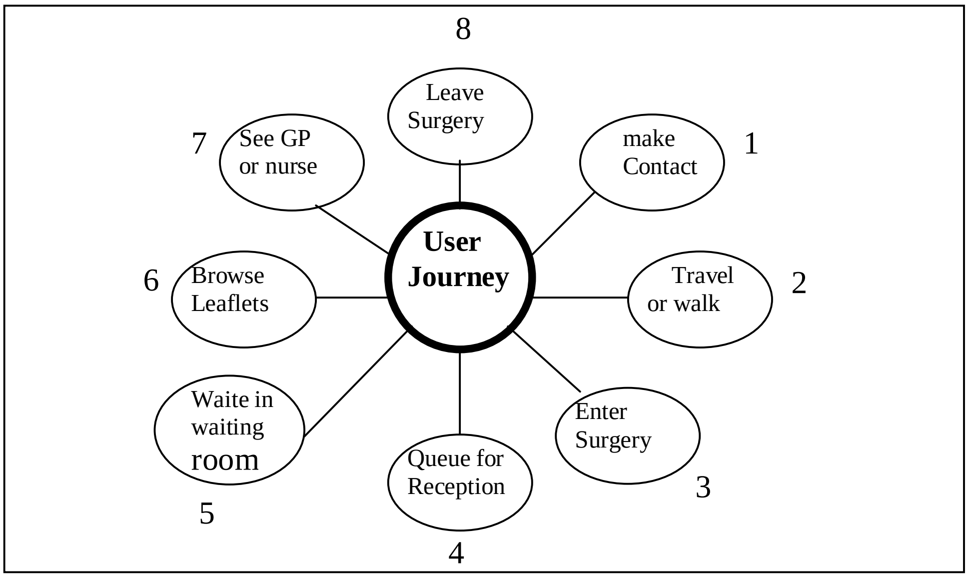

Figure 2: A typical user journey to a doctor's surgery

Having walked into the surgery, the user will interface with the receptionist. This can take the user a while until they are attended to because of the queue. At stage five, the user is asked to take a seat in the waiting room to be seen by either the GP or practice nurse. Once the user secures a seat, they then tend to wander around, usually looking for something to keep them occupied such as browsing through the surgery leaflets or a magazine. The user will then be seen either by the GP or practice nurse and departs the surgery either with a positive experience or otherwise depending not only on the quality of care received but also on the quality of process of accessing and exiting the 'servicescape'.

2.5 How do PCTs measure user experience?

The key role of a PCT within the NHS is the development, administration, provision and delivery of healthcare to the local community, in conjunction with its partners. Improving the health of the community is not simply about providing the best health care services, but also about delivering the right mix of health promotion activities and social care services. This differs from the key role denoted to other trusts such as acute and mental, which is the treatment and curing of illnesses, rather than the initial prevention, Salford PCT [10].

A review of PCT services to make them fit for purpose for staff and patients, rather than systems, has led inevitably to a radical rethink in the way that the PCTs' healthcare services are provided. This new way of thinking about primary healthcare has affected almost every area of the PCTs activities, as health and wellbeing cannot be separated from housing, employment, the environment and a thriving local economy.

An examination of previous work carried out on behalf of the Commission for Health Improvement (CHI) and Patient Environment Action Team (PEAT) has shown that the basis on which patient experience was interpreted cannot be traced back to their roots. From a research perspective, an understanding of the basis is important to ensure the reliability and validity of the outcomes. Many questions currently remain unanswered which impact on the reliability of current measures.

CHI identifies five domains for measuring patient experience [10], namely:

- Access and waiting;
- Safe, high quality, coordinated care;
- Better information, more choice;
- Building relationships;
- Clean, comfortable, friendly place to be.

Their definition of patient experience is based on the following:

- Preliminary discussion with stakeholders in the NHS and Department of Health (DoH) about issues to address in the surveys;
- Review of the existing literature and surveys;
- Focus groups with Acute Trusts' users to identify what matters to them; and
- Drafting, testing and piloting the questionnaire for 2003/2004 carried out with patients who recently experienced Acute Trust services.

Further investigations indicated that the development of the questionnaire used by CHI to assess user experience within PCTs has followed the same developmental process as for other NHS Trusts. This process is regarded by the researchers as highly alarming, because it does not address issues that directly matter to the service users in PCTs.

3. Research Methodology

3.1 Methodology

The purpose of this study was to explore how NHS PCTs service users experience 'healthscape' in pursuit of service excellence. A mixed (phenomenological and positivist) approach was used, allowing the user's own interpretations to be discovered. Further, this study sought to explore key impressions of service user experience as an integral part of service excellence in NHS PCTs, initially through a pilot study, and subsequently through a questionnaire-based study. Hence the mixed approach involving a combination of both qualitative and quantitative methods has been used for this research. Qualitative and quantitative methods can be seen as complementary, with different emphases in different disciplines, but sharing a heritage of logical thought and empiricism, Preece [11].

Case studies have been employed as a part of the research strategy embedded in a positivist and phenomenological framework, Yin [12], which does not show a concrete use of single or multiple case studies, but rather the whole research process as the case. By using multiple approaches, the researchers were able to triangulate the data gathered in order to generate better judgement on their interpretation. Yin *et al*, [13] supports this view stating that the case studies that adopt such methods are rated more highly than those that rely only on a single source of data. In addition, the case study approach as Yin [12)] suggests, is the preferred strategy when 'what', 'how' or 'why' questions are being posed, and when the focus is on a contemporary phenomenon within a real life context.

Five methods of enquiry are employed for data collection, and as a means of examining customer (service user) experience and views in pursuit of service excellence within the case study organisation. These are: literature survey, pilot study, focus groups, questionnaire and workshop.

3.2 Literature survey

The literature survey was based on text books, historical research and refereed journals on a number of relevant topics including performance management, service quality, customer satisfaction and service excellence. Literature review of existing and publicly available reports and documents regarding current user satisfaction measurement was also undertaken. This represented the first phase of the research and` set the background for future work.

3.3 Pilot study

Pilot studies refer to either a mini-version of a full-scale study, or a specific pre-testing of a research tool or method, van Teijlingen and Hundley [14]. The aim of this pilot was to identify service user experience. The study required an exploratory case study to be undertaken.

Preliminary data was acquired through face-to-face semi-structured interviews with eighty residents in the catchment area of Salford. This provided an opportunity to explore and gain insights into, and clarification of how impressions of 'healthscape' experiences were formed.

The semi-structured interviews consisted of two parts. The first part compiled general information such as local gender, age, employment, home ownership, ethnic background, disabilities and the use of PCT facilities (doctors' surgeries, dentists, chemists opticians, other) in the last six months.

The second part addressed the users' overall impressions of PCT 'healthscapes' in Salford. It addressed issues related to both their impressions of the service as well as of the environment in which services are delivered (see table 2).

Table2: Key impressions of service user experience

Issue	Service	Frequency	Environment	Frequency
Politeness of receptionist	√	78/80		
Waiting Time	√	77/80		
Friendliness of receptionist	√	67/80		
Understanding of receptionist	√	65/80		
Helpfulness of receptionist	√	62/80		
Quality of care	√	57/80		
Comfortable Waiting area			√	49/80
Appropriate furniture			√	41/80
Children play area			√	37/80
Quantity of care	√	35/80		
Choice	√	34/80		
Cleanliness			√	36/80
Up to date magazines and news papers			√	33/80
Car parking			√	29/80
Lighting			√	27/80
Communication			√	20/80
Colour			√	25/80
Security			√	18/80
Disabled facilities			√	10/80
Access			√	07/80
Signage			√	03/80

3.4 Focus groups

The next phase of the research would be based on a number of focus group sessions facilitated with users of Salford PCT 'healthscape'. This is deemed to be crucial for the rigor and reliability of the measuring instrument. According to Miles and Huberman, [15] the best way to improve credibility and acceptance is through the improvement and the rigor of techniques for data collation and analysis.

3.5 Questionnaire

The fourth phase involves the use of postal questionnaires to measure customer (service user) experience in Salford PCT, based on issues identified in the interviews and focus groups. Postal surveys are a powerful, effective, and efficient alternative to the telephone survey and personal interview. The postal survey was deemed appropriate as it enables easy access to population samples. Respondents are more likely to provide honest answers than they do to other interviewing methods, ASA Series [16]. Writers perceive that the biggest disadvantage to postal surveys is a low response rate, ASA Series [16], which is not necessarily true. Good planning can lead to response rates as high as those obtained in telephone or face-to-face distribution techniques, ASA Series [16].

3.6 Workshop

The final phase of the research would involve the validation of the findings through a workshop with a panel of experts and participating PCTs. A major benefit to be derived from this will be to gain an understanding of what has already been done, what needs to be done, and where potential opportunities and/or barriers may lie. It would also assist with the verification of data, and help generate a rich picture of FM service excellence practices and the impact that they may have on the user experience in NHS PCTs.

4. Case study

4.1 Case Study Organisation

Salford is the fourth most deprived local authority area in the North West of England, and 28th nationally. The city has considerable health inequalities as a consequence of lower educational attainment and unemployment, access to services and huge differences in lifestyle.

Salford PCT serves a population of around 234,000 people who are cared for via 61 GP and 41 dentist practices. Children born and raised in families of lower socio-economic groups are more likely to experience declining health later in life, and Salford residents have a life expectancy almost three years below the national average for men and almost two years below for women.

The PCT is a key participant in Britain’s biggest ever project to improve frontline health and social care facilities and services and has been driving forward radical plans for new health and social care centres, funded via the Manchester Salford and Trafford Local Improvement Finance Trust (LIFT).

4.2 Research Findings

The interview schedule took place between June until September 2004. The lead researcher visited each venue, and the duration of the interviews varied depending on the number of users at the different venues. In order to ensure complete and accurate records of interviews, hand written answers were taken. Each user was asked for the details of their impressions formed about the healthcare delivery and the environment in which it took place. Several key issues were identified, and the users were asked for more details wherever necessary. After the interview schedule, all the notes were transcribed to analyse the interview findings. These were compiled in table 2, and highlight the fact that user impressions reveal important facts as to whether the PCT is responding to the needs and desires of the healthcare service users, and helping to facilitate the provision of 'healthscape'.

However, as with any investigative process, there are always potential difficulties to be encountered somewhere along the line. Therefore an evaluation was made by the lead researcher to identify any difficult elements to the study that could hamper the progress and successful outcome of the research. It was found that some of the service related elements detailed above may be difficult to determine because of the subjectiveness of some of the measurement criteria. For example, in determining how polite and friendly the receptionist is, it may be difficult to analyse real-life scenarios and quantify how much politeness and friendliness have been dedicated by the receptionist.

The next step in this research was therefore to identify and prioritise the demands of the service users of healthcare delivery within Salford PCT through a questionnaire, based on the outcomes of the pilot study. From this basic mapping (table 2), and the data set that underpin it, it was possible to prioritise and show the service delivery related impressions in terms of importance.

As table 2 demonstrates, out of eighty service users interviewed, politeness of receptionist was the most highly cited occurring seventy eight times. Waiting time came second with seventy seven citations, friendliness of receptionist scored sixty seven citations, and so on. Quality of care came sixth with fifty seven citations, and choice came eight with thirty four citations. This highlights that an improvement in the politeness of receptionist, will greatly improve the perception of healthcare services in the PCT.

On the other hand, an analysis of key environment-related impressions (table 2) shows that a comfortable waiting area was most important with forty nine citations. This along with appropriate furniture (forty one), children's play area (thirty seven) and cleanliness (thirty six) were more important to healthcare service users than choice (thirty four).

5. Conclusion

Although changes in healthcare performance measurement in the NHS are currently in the process of being implemented, the earlier findings of this study still apply in terms of the relevance and reliability of previous measurement tools in use for measuring PCT performance. Previous measurement criteria did not truly reflect user needs and requirements to ensure the measurement of user experience or service excellence.

The mixed approach adopted by this study has enabled the in-depth exploration of user experience in the Salford PCT using a variety of research tools. These highlighted the fact that users found the highly subjective areas of politeness, friendliness and comfort very important. These have never been previously measured in determining user experience.

From a Facilities Management (FM) point of view, the emergence of FM related issues from seventh position down on the grid (table 2), with the exception of choice, may be taken in two ways. The first is that they are not as important to users of PCT services as the people and quality and of care issues. However if we consider the fact they represent thirteen out of the top twenty-one citations for user experience, we begin to see the importance and contribution of the FM function to user experience in this sector.

Another emerging concept is that of the healthscape, i.e. viewing the delivery of healthcare services in the user's perception of enjoyment of consumption. This forms the basis of future work to be undertaken in this research. It also represents for Salford PCT, the first step from delivering a quality service towards service excellence.

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Usability of Hospital Buildings - Is Patient Focus Leading to Usability in Hospital Buildings?

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Abstract

Global Engineering and Manufacturing in Enterprise Networks, GLOBEMEN, is a three-year (January 2000- January 2003) research project with an estimated effort of 1000 person-months. It is part of the global Intelligent Manufacturing Systems (IMS) program and the project consortium has 19 participant organisations dispersed across different IMS regions ....

Experience from several hospitals indicates challenges according to usability of hospital buildings, associated with the rapid and continuous changes in the hospital organization and use of technology. Experience also shows that the hospitals are having difficulties in adapting existing buildings due to new requirements and user needs. The quality of hospital buildings depends on the buildings ability to absorb organizational, operational and technical changes.

Usability is defined as the *"….effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment"* (ISO 9241-11, 1998). According to this definition, a product's usability is determined by 3 key factors:
Effectiveness – whether users can achieve what they want to do with the product.
Efficiency – how long it takes them to achieve it
Satisfaction – their feelings and attitude towards the product

Hospital buildings are characterized by major complexity, and hospital operation are affected by rapid changes and trends. Planning and design of hospital buildings reflect a view of society, humanity and patients at all levels, from the location, overall concept and urban plan, down to the architecture and design in the immediate surroundings of the patients and staff. In recent years there has been a changing trend in cultural and ideological aspects due to hospital operation, and an increased focus at the patient, patient's rights and participation in the treatment situation.

Will this ideological change affect usability of hospital buildings? This paper is discussing some of those challenges arising according to the relationship between usability of buildings and a patient focused hospital, and is discussing whether patient focus is leading to usability of the

hospital buildings. These issues are discussed in relation to planning and design of the St. Olav’s Hospital in Trondheim.

Keywords: Building performance, hospital, patient focus, usability.

1. Challenges in hospital buildings regarding technical and functional aspects

Hospital buildings are characterized by major complexity, and hospital operation are affected by rapid changes and trends. In accordance to Jonassen et al. [1] the supply of health and care are continually changing world over, and the speed of change is ever accelerating. In the last decades the hospital sector has been influenced by a tremendous development within ICT and medical technology. This has led to more focus on adaptability of existing buildings.

Planning and design of hospital buildings are on all levels reflecting a perspective on the society, human beings and the patients, from localization, concept and town planning, down to architecture in patients and hospital employees close surroundings. A brief summary of hospital organization and design in the different eras is given below, based on how changes in this perspective have affected organization and physical surroundings within the hospital.

In recent years there has been a changing trend in cultural and ideological aspects due to hospital operation, and an increased focus at the patient, patient’s rights and participation in the treatment situation. This paper is focusing how ideological changes due to patient focus is affecting usability of hospital buildings. Will a stronger patient focus in the planning, design and daily hospital operation lead to greater usability of buildings? We will discuss some challenges in handling the relationship between usability of the buildings as physical surroundings, and whether a stronger patient focus is leading to usability of the hospital building. In the paper we will use the case St. Olav’s Hospital in Trondheim, and the planning and design of this project. St. Olav’s Hospital is a large ongoing redevelopment project of the old regional hospital in Trondheim, and the project has a pronounced objective of a high degree of patient focus in the hospital development.

Our studies are based on literature studies, the theoretical framework developed by CIB TG51 “Usability of buildings” [2], and studies of project documents and interviews from the St. Olav’s Hospital project. This is a preliminary study, where we develop the research questions for a following PhD-study.

1.1 A brief historical summary

In the 18th century a demographic growth in the population, wars and epidemics resulted in establishing institutions with a diffuse distinction between treatment, detention and penalty.

Gradually the treatment aspect appears more and more clearly, foundation of medical science gains greater scientific understanding, and hospitals arise as separate institutions [3].

The physical surroundings in hospitals were a large problem in the public health service in the 19th century. Florence Nightingale wrote in her “Notes on Hospitals” (1859) that the death rate at the largest hospitals in town was considerably exceeding that of patients suffering from the same diseases, treated other places. In her “Introductory Notes on Laying-in-Institutions” (1871), she pointed at several cases of illness caused by physical surroundings, and referred to design, light, air and ventilation as important elements in hospital buildings [4].

The development within the hospital sector in recent decades has gone from the pavilion hospital, via the block hospital, to the “neighbourhood hospital”, representing the hospital model of today. This has happened based on the development in medical technology, and the changes in main nursing philosophy have been the driving forces behind this development.

The pavilion hospital emerged as a consequence of the problems at the 19th century, and was focusing daylight, air, ventilation to offer satisfying hygiene for the patients. The hospital buildings were divided into separate pavilions, which were gradually connected with glass corridors, to simplify the work for the employees and transportation of the patients.

The major hospital development in Norway has taken place periodically, being at its maximum in the 1950ies and the 1970ies [5]. There was a large expansion in the health sector in the 1950ies, and the planners adopted organizational models from the industry aiming to increase the efficiency and productivity in the hospital sector. The nursing philosophy was based upon specialization, hierarchy, centralization and top management, and this hindered communication between the patients and the employees. Satisfying the patients’ physical needs was in focus, and little attention was shown the psychological, social and spiritual needs of the patients. The block hospital was developed as a response to the quantitative objectives related to efficiency and requirements due to the technological development at that time. This was also the dominating trend internationally, among others in Germany, where “medicine in focus” was the leading ideology. In the 1960ies and 70ies the functionalism was the predominant style in the hospital architecture. Hospitals were designed and built as “nursing factories” in high-rise blocks, focusing quantity and centralization of the hospital activity. Esthetical quality was not given priority.

In the 1970ies a critical debate related to the hospitals as “nursing factories” arose, and the basic attitude towards hospital planning started to change. Bad working conditions and mechanical treatment of the patients was focused in the media, and the centralization and the de-humanifying due to the physical surroundings in the hospital was strongly criticized. This lead to a search for new operational models in the hospital, and a development towards hospital projects of smaller scale, decentralization, and a higher degree of intimacy and tighter contact between the employees and the patients [6].

1.2 Patient focused hospital

As mentioned above, in recent years there has been a changing trend in cultural and ideological aspects due to hospital operation, and increased focus at the patient, patient's rights and participation in the treatment situation [7]. Hospitals have moved from being focusing efficient treatment to a higher degree of patient focus. The patient is no longer regarded merely as a "product" being in hospital to get "fixed", and respect of the patient is in a higher degree ensured in the hospitals of today. Besides scarce economical frames has been leading to further focusing efficient examination and treatment, a high exploitation of the resources and productivity, and this is changing the way the hospital is being operated.

An option of freely choosing hospital for treatment, competition from private actors within the hospital sector, together with the threat of outsourcing of services, affects the requirements of change within the public hospital sector. On this basis, the hospitals planned and built today give the expression of being founded on another fundamental attitude towards health and care than the traditional, by putting the patient in focus.

The organization and design of several projects is based on the Planetree philosophy, which is a philosophy especially focusing the patient and seeks to improve the medical treatment seen from the patient's point of view [8]. The fundamental values of the Planetree philosophy is trust, intimacy, dignity, security and confidence, holistic care and treatment, information, participation in decision-making, health promoting physical surroundings, and network support. The philosophy emphasizes to personalize and humanize the hospital treatment, and make it less unfamiliar both for patients and relatives. The Planetree philosophy is besides representing a value based and holistic patient perspective.

1.3 Usability of hospital buildings

Experience indicates challenges according to usability of hospital buildings, associated with the rapid and continuous changes in the hospital organization and use of technology. Experience also shows that the hospitals are having difficulties in adapting existing buildings due to new requirements and user needs.

The quality of hospital buildings depends on the buildings ability to absorb organizational, operational and technical changes. To meet these changes it is necessary to design buildings with an appropriate physical and organizational adaptability over a time period. Hospital projects are characterized by an extensive planning and construction period, often lasting 10 – 15 years. During this period the project assumptions and the user organizations needs are changed, due to rapid development in technology, organizational changes and treatment methods. Not seldom we experience a mismatch between the user organization and the building at the completion time, resulting in continual building changes.

2. Operationalizing the concepts

Both the terms usability and patient focus are hard to make operational, and are according to this often difficult to measure and evaluate in a completed hospital building.

2.1 Usability of buildings –theoretical framework

Until lately it is written and done little research on usability in buildings. Several research projects are done due to aspects concerning this concept, but few are studying the connection and dependence between the aspects. The term is vague and little tangible. The concept of "usability" is widely known in relation to applications within product design, information technology and web-design, related to user friendliness and user interface of the system.

A CIB Task Group 51 "Usability of buildings" has been created to apply concepts of usability, to provide a better understanding of the user experience of buildings and workplaces. Usability is here defined as the *"….effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment"* [9]. According to this definition, a product's usability is determined by 3 key factors:

Effectiveness – whether users can achieve what they want to do with the product
Efficiency – how long it takes them to achieve it
Satisfaction – their feelings and attitude towards the product

Usability means that systems are easy and fast to learn, efficient to use, easy to remember, allow rapid recovery from errors and offer a high degree of user satisfaction. It also means bringing the user perspective into focus. The term usability describes whether or not a product is fit for a specific purpose [10]. Usability, or functionality in use, is concerning the buildings ability of supporting the user organizations economical and professional objectives.

The concept of usability of buildings can be approached in four ways [11];

1. Criterions and parameters affecting usability
2. Usability from different stakeholder's point of view
3. The time perspective
4. Workplace and context

According to the patient in focus it is especially interesting to discuss the second approach, usability from different stakeholder's point of view.

2.2 The patient in focus

The organization and design of several projects is based on the Planetree philosophy. The last project in this development is new St. Olav's Hospital in Trondheim, a project designed in accordance with the hospital ideals of today. According to Dilani [12] no hospitals has so far been implementing the Planetree philosophy as extensive as this project. The architectural competition for the project, accomplished in 1995, was based on treatment, nursing and care to be done with the patient in focus. The term “patient in focus” is defined as a holistic view of the patient and a production oriented view on the organizational structure in the hospital. The solution for St. Olav’s Hospital is a decentralized hospital with smaller, partly autonomous units in separate buildings; integrated centres in independent blocks. The fundamental idea is that the patients needs and wishes is the basis for all planning. Emphasis is made on dignity and participation of the individual patient. Through a patient focused treatment the patient is to experience continuity and connection during the treatment.

The staff is brought together around the patient, as opposed to earlier, when the patients were transported from department to department to receive the necessary treatment. The patient needs to deal with less people, giving a more humane atmosphere. Every building unit is of a smaller scale than a traditional centralized hospital complex.

2.3 Case: St. Olav’s Hospital

St. Olav’s Hospital is based upon a transformation of the existing buildings at the original site. 80% of the existing buildings are being demolished, and the remaining is rebuilt. The project contains 197 500 sqm new buildings. Rehabilitation and new building is done step by step over a period at 11 years.

The main objective of the project is to create an efficient and professional hospital. The development plan for the project [13] states “the patient in focus” as a main objective, and is also describing seven other objectives for the completed hospital [14], among them flexibility, which can be related to usability. The hospital is based upon a decentralized centre model, where each centre is representing self sufficient units. Necessary changes are assumed to be solved within the centre, giving few effects and consequences for the rest of the hospital.

Several concepts are affecting usability and patient focus in the hospital project [15];

- Area flexibility (possible extension and addition of buildings)
- Generality (standard design solutions)
- General centre (basic principles for building structure, communication, organizing, functional division, volumes, exterior facades, use of materials)
- Structural flexibility (focusing possible rebuilding and functional changes)
- Technical flexibility (possible changes in capacity)

In this context it is especially interesting to describe and discuss the topics *generality* and *general centre*, due to patient focused hospitals.

2.3.1 Ideas for developing patient focused design solutions, with the bed cluster as an example

The bed cluster (“sengetun” in Norwegian) is a physical and organizational model representing one way to organize patients’ rooms in the wards. According to the principal architect in The St.

Olav's Hospital Development Project, part of the challenge in planning and design of the new hospital is to transform an existing physical and organizational structure into a modern hospital according to the objectives for efficient operation and patient focused care.

The holistic model "Human and material resources" (figure 1), is developed to discuss, together with other aspects, generality in physical solutions. According to this model, hospitals can be divided into two sectors which have different sets of resources. One sector is based on human resources, and the other sector is based on material resources (buildings and equipment). Achieving value in hospital planning and operation can similarly be described in two ways. One sector describes quantifiable objectives, such as the number of health services delivered, while the other sector is based on values associated with the human experience of quality, including user satisfaction.

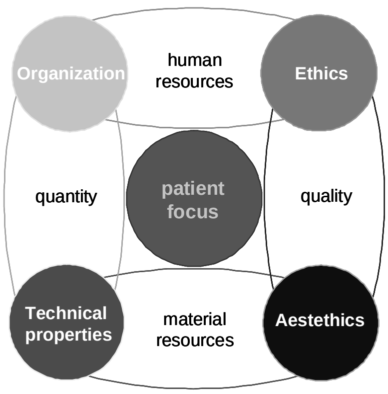


Figure 1: The holistic model "Human and material resources" [16].

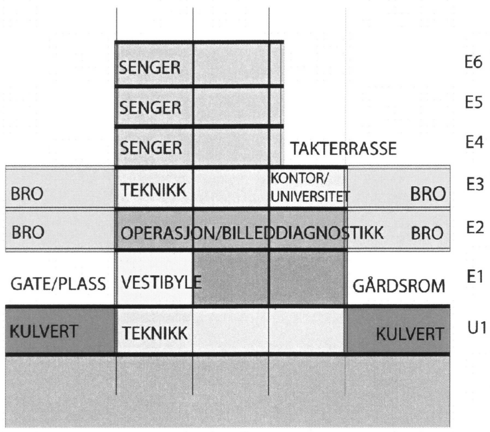
The hospital organization can be placed in the intersection between the human resources and the quantitative resources. In St. Olav's Hospital one of the goals are to build up an organization for best possible use of the combined resources of human capacity and competence in the hospital. In the intersection between the human resources and the qualitative values, we find ethics, where visions about attitudes and the human perspective must be defined. This is, among other philosophies, put into system by the Planetree organization. In the intersection between the quantitative and the material, we find the technical properties, defined as functionality and technical quality of buildings and equipment. In the intersection between the qualitative and the material resources aesthetics are created.

This holistic model describes various aspects of the hospital organism, and shows how various aspects affect each other in a development process. According to the principal architect, the development process will include all the aspects, whether they are taken into account or not. Objectives and visions for developing the hospital organism are placed in the centre of the model, so that all the secondary aspects are directed at a common focus. In St. Olav's Hospital, the vision has been defined as operational efficiency (production focus) and patient focus (customer orientation). This involves awareness of both quantitative and qualitative values, and the whole model is activated.

The bed cluster design provides, according to the principal architect, an opportunity to develop a more practical, social and building-related environment for patients and staff. The patients' rooms are grouped around stores for supplies and workstations for the staff which care for the patients. At St. Olav's Hospital there are 6 – 8 patient rooms per bed cluster, and the clusters are placed in series with common supporting rooms in between.

2.3.2 General centre

The concept "general centre" is developed as a part of the hospital project. The target of this has been to develop a model to take care of common qualities and solutions in the project, general for all centres, corresponding with the superior objectives. "General centre" includes basic principles for building structure, communication, organizing, functional division, volumes, exterior facades, use of materials and so on, to assure superior structure, character and totality. The concept introduces guidelines for physical design, and is meant to be a "prototype" for the development and design of each centre. This is considered to be an important feature in gaining flexibility (figure 2).



3rd - 5th floor;	*wards*
2nd floor;	*mezzanine level for technical services over medical functions requiring technology*
1st floor;	*connecting bridge, theatre, radiology, recovery*
ground floor;	*policlinics, day areas, cafeteria, kitchen for the centre, auditoria, rented areas*
Basement;	*underground passages between centres, technical functions, bed equipment stores, locker rooms and cleaning unit.*

Figure 2: General centre [17].

The concept of general centre comprises the following principles;

- identical localization of functions on the floor plans (figure 2)
- functions belonging to one centre can easily be expanded into the adjacent centre
- logistics due to transverse function is improved
- concentration of activity at inconvenient time
- a continuous surgery area at the 1st floor
- a continuous university area at the 2nd floor

3. THE BUILDING VERSUS THE EFFECT OF THE BUILDING

The relationship between usability of a building and a user focus is discussed in a case study draft report [18], carried out as the Swedish part of the CIB TG51's work in 2003. In the report, which is a work in progress, it is expressed that *"We can define functionality as a property given to an artefact in order to create a practical effect. An important effect can be described as usability. (…) We all know that functionality alone does not make a certain artefact usable. The technical and physical properties of the artefact and its theoretical potential to deliver a certain effect do not automatically make it usable in the real world."*

The same aspect is discussed by Granath [19]. According to Granath the Swedish society traditionally are based upon production of goods. The rationalist way of thinking is the dominating, and it is focusing at what theoretically should happen if the product is produced in a specific way, rather than focusing the result of what is done. There is however also another knowledge, even if it often is secondary. In state of being a user, we confirm how the products are working for us, whether we like them or not, in what way they are affecting our lives, and whether we think they are beautiful or ugly and so on.

Granath says that in the first perspective we are talking about buildings and products (the artifact in figure 3), in the other perspective people doing things (the effect of the artifact). We are measuring and evaluating the shape, quality and quantity of the product, but should rather be talking about how the product is meeting the users needs and requirements. We are focusing functionality believing this will lead to what really is crucial, being usability. We believe that the problems are solved when we succeed to develop tools for solving them, and think that the effect always is the desired. In figure 3 these two perspectives are visualized;

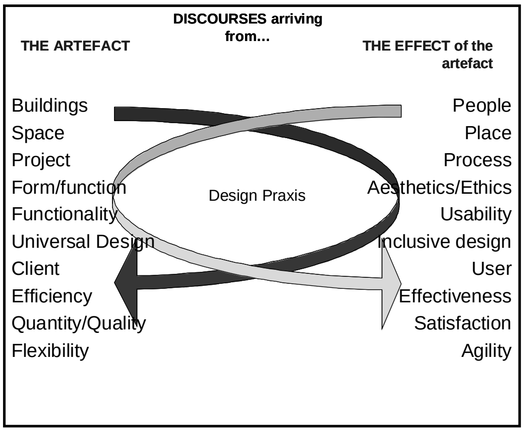


Figure 3: The artifact versus the effect of the artifact. [19]

The traditional way of thinking is visualized by the dark arrow in the figure, where the range of ideas is based on the product, and where the conclusion is a technical solution to a humanistic problem. The new and needed way of thinking is that there always is, in both new buildings and in a buildings phase of use, a need for developing knowledge starting on the right side of the figure, based on the core organization, and further to use tools and techniques on the left side of the figure to develop relevant solutions judged based on the thinking of the right side in the figure. This new way of thinking is represented by the light gray arrow in the figure. To achieve this, a change of attitude is crucial.

The model in figure 3 gives a good picture of the traditional versus the new way of planning and operating a hospital. Traditionally it has been usual to develop hospital projects in line with the red arrow, and focusing “the nursing factory” and “the medicine in focus”. St. Olav’s hospital is based upon a fundamental reorganization of the hospital activity. As we see in section 2, the planning and development of this project is based on the right side of figure 3, in a higher degree than most of the other hospital projects the latest years, by emphasizing the patient focus in the degree that is done. This can however cause some challenges related to the traditional way of building a hospital and organizing the hospital activity [20].

3.2 Possible challenges that might arise

3.2.1 Different actors – different perspectives on usability of the buildings

There are several approaches to the concept of usability. In the paper *“Usability of buildings. Theoretical framework for understanding and exploring usability of buildings” [21] four approaches to the concept are described. The second approach describes how different stakeholders and organizational levels have different perspectives considering usability of buildings; “The terms usability, effectiveness, efficiency and satisfaction is interpreted and understood in different ways. Productivity and effectiveness are generally emphasized as a strategic management issue, while individual workers are engaged with user satisfaction and practical aspects in their daily working situation.”*

In a hospital project “the users” consist of several actors, both hospital employees, patients, primary health service and so on. It is impossible to involve all these actors directly in the planning of the project in a high degree, and the user involvement in the project is due to this often based mainly on participation from the hospital employees.

The planning process in St. Olav’s Hospital is accomplished with extensive user participation, consisting of mainly hospital employees. As mentioned earlier patient focus is emphasized as crucial in the new project, and the challenge is therefore whether the hospital employees and the architects designing the project have the necessary knowledge and ability to take the patients’ perspective in the process of planning a patient focused hospital. Do the actors represented in the planning phase manage to represent other actors’ perspectives in a good way, so that the new hospital buildings are usable for the patients? Interviews done in 1999 indicates that several actors are sceptical to whether this is sufficient to gain a patient focus, because of the medical employees being mostly engaged in focusing their own medical discipline and specialization; *“The hospital employees think they are patient focused, but they are too close to the patient to see that they are not really patient focused.”* [22].

The Örebro case study, accomplished as the Swedish part of the CIB Task Group 51 work, still points at the value of user participation in the process, and concludes that *"From this case we might conclude that participation has a large value for performance and satisfaction in the near future after the move in."* The results of the case study confirm the importance in longer terms of user participation in these kinds of building projects; *"Örebro County has a long tradition of involving the users in the design of places for work. It is a natural part of the culture and is not regarded as an event. It is interesting to discuss how this culture of participation has an impact on trust between employees and employer and how that in turn makes it possible to impose even more drastic changes like the change of technology in the radiology department."*

3.2.2 Involvement of the users in the planning – leading to usable buildings?

We have seen that rather extensive user participation is used as a mean to implement the concept of patient focus in the new St. Olav's Hospital. Some actors are questioning the user participation in the project, and whether this is contributing to tailor made buildings rather than flexibility and usability in a long time perspective. In an evaluation of the project done in 2003 [23], it is concluded that the experience so far is that the users not are sufficiently farsighted. They are mainly concerned about their situation and activities ongoing today, and relate their own transferring of information to this, instead of being visionary and future oriented. The result is often too much focus at reaching solutions, at the sacrifice of focusing functional claims. An important challenge is therefore to balance the individual users need for tailor made solutions with a more superior need for long-term future solutions.

Via the evaluation project some actors also express that the concept "general centre" has had too little validity in the first phase of the building project. It has been too easy to do changes and exceptions from this standard, and this has resulted in different solutions in different centres. This might be an indication on that the guidance developed due to generality and general centre have been influencing the design of each individual centre in a less degree than desired

3.2.3 Is the patient focus affecting the traditional hierarchy in hospitals?

The interviews unveil a disagreement related to fully base the new hospital project on a patient focused ideology, due to the organizational changes needed to be done. Professional arguments are used against this ideology, and it seems like a number of hospital employees, especially within the medical profession, experience the increased patient involvement and openness in the hospital organization as a threat against their own professional integrity and expertise. It is expressed that a hospital organization according to patient focused thinking will cause a fragmentation of specialist environments and offer jobs being less professionally attractive.

Accentuating patient focus as something new and revolutionary is comprehended as provocative by the medical profession; *"The patient focus is not something new. We have done this all the time!". "It is a provocation to the doctors to say that they so far not have been doing patient focused work."*

The patient focused thinking is assuming increased communication and cooperation between the different professional disciplines than earlier. This will be crucial to develop common knowledge beneficial to the patient. The hospital is traditionally based on disciplinary development of knowledge, because it is this that gives professional status. Some actors within the medical profession are afraid this transdisciplinarity will fragment existing specialist environments, and establish interdisciplinary areas in competition to the existing specialist environments.

Implementing a patient focused thinking and the Planetree philosophy in the hospital assumes development of a socially robust knowledge within the organization. Patients and relatives must perceive the knowledge developed in the hospital as credible and functional, and an assumption for this is increased openness, access, participation and involvement than the traditional.

A change in the hospital organization considering patient participation and involvement in the treatment situation promises that it is necessary with a general change in attitude in the hospital organization, according to the traditional view of the patient as an object or a "product". These kind of changes seems to feel like a threat for the traditional hospital organization, since the existing organization is needed to be questioned critically.

4. CONCLUSIONS

In this paper we discuss some of the challenges for planning, design and operation of patient focused hospitals. Usability forms the basis for this discussion. We are using a theoretical framework for exploring usability presently under development by CIB Task Group 51 and the Planetree philosophy regarding patient focused hospitals. The theoretical discussion is related to the new university hospital project in Trondheim, where the project organization has an expressive goal of achieving both a greater efficiency and a more patient focused hospital.

Usability is defined as the "*….effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment*" (ISO 9241-11, 1998). According to this definition, a product's usability is determined by 3 key factors:

Effectiveness – whether users can achieve what they want to do with the product
Efficiency – how long it takes them to achieve it
Satisfaction – their feelings and attitude towards the product

In this paper we have discussed some aspects considering how these 3 key factors are connected to a patient focused ideology. The dominating discussion is related to user satisfaction, as an important element of gaining usability of a building. Evaluations show an immediate relationship between a stronger patient focus and satisfied patients. Implementing a patient focused ideology might however cause some challenges related to usability of the building, and thus both the hospital building and organization;

- Different actors have different perspectives on usability of buildings. The planning process in hospital projects is often accomplished with extensive user participation, but this is consisting of mainly hospital employees. The question is due to this whether the hospital employees and the architects have the necessary knowledge and ability to take the patients' perspective in the process of planning a patient focused hospital.
- Will involvement of the users in the planning lead to usable buildings? We have seen that rather extensive user participation is used as a mean to implement the concept of patient focus in the new St. Olav's Hospital. Some actors are questioning the user participation in the project, and whether this is contributing to tailor made buildings rather than flexibility and usability in a long time perspective.
- Another question that is important to emphasize is the relationship between efficiency and a patient focused ideology, and whether these are incompatible. Parts of the medical profession fears that founding the new St. Olav's Hospital on a patient focused ideology will result in a fragmenting of specialist environments, and that this will cause a decrease in efficiency.

These questions and topics will be taken further as part of a PhD-study at the university. This PhD-study will be focusing usability of buildings related to a stronger patient focus, and will be discussing the relationship between efficiency at the one side, and a patient focused ideology on the other side.

5. ACKNOWLEDGEMENTS

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Exploring tenants' perceptions of their homes in the UK social housing sector

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Abstract

In recent years, many researchers in marketing have stressed the importance of the need for satisfying customers. They believe that a better understanding of customer requirements leads to successful business. In 1998, the Egan report identified key drivers which needed to be addressed if the UK construction industry was to benefit from the radical change experienced in other industries. The UK housebuilding industry has long had difficulties in satisfying its customers and has now been put under pressure to make strenuous efforts to modernise itself. Egan specifically considered social housing as an area where significant improvements could be achieved. In reviewing the sector, the potential to lead change in housing via the social housebuilding programme was highlighted. As part of this initiative, a set of 12 key performance indicators were identified, and one of them was customer satisfaction.

In this context, a four-year research project began in 2001. The project includes 12 registered social landlords, which have formed a consortium, and one of the objectives is to achieve higher customer satisfaction through using a new procurement system. In order to investigate the satisfaction level of those who lived in the consortium's schemes a post-occupancy questionnaire survey was designed. Five themes for the customer satisfaction KPI were identified prior to the project: space and facilities, ventilation, sound insulation, ease of use, and after-care. These themes form the main part of the questionnaire. The questionnaire also contains questions as to general satisfaction and satisfaction with service provision/decision-making participation.

This paper first presents the survey results. The survey was conducted in two stages in 2003 and 2004, with 3 RSLs and with a total of 8 schemes that reached the end of the 12-month Defect Liability Period. Ninety-five questionnaires were sent out and 34 were returned (the 35.8 per cent response rate). The findings will be fed back to the consortium to improve the products and performances. Then, the present paper discusses organisational problems in terms of the management of the survey. There has been difficulty in conducting the survey across the housing associations. In order to understand the nature of the problems, informal discussions were carried out with relevant officers in these housing associations. It has become clear that there has been a lack of understanding between the consortium and the member housing associations. An analysis of organisational problems will help the consortium to act more efficiently.

Keywords: Post-occupancy evaluation, tenant satisfaction, housing quality, communication

1. Introduction – background

In recent years, many researchers in marketing have stressed the importance of the need for satisfying customers. They believe that a better and deeper understanding of customer requirements leads to successful business. This is because it is more profitable to keep the same customers than to do one-time sales with different customers. Customer satisfaction leads to a higher customer intention of returning to the same provider and of making positive referrals; and such customer loyalty and referral lead to an increase in company profits. Customer retention, therefore, ensures a steady stream of future cash flow. Conversely, dissatisfied customer may switch providers and be a source of negative advertisement. In this regard, an analysis of 'defectors' and their views on the company provides useful information to improve the business [1, 2]. There is, however, one aspect that should not be forgotten in this 'satisfaction – loyalty' formula: some people are forced to remain as customers because they have no or little choice. This concept of *false loyalty* tells us that we should not neglect investigating customer satisfaction even though they remain with the company [1, 3].

So, what makes customers satisfied? There are several elements that underpin customer satisfaction: customers' perception/evaluation of tangible service performance, such as staff's willingness to help and provide information, attentiveness, friendliness and ability to understand customer needs [4]; employees' satisfaction because it affects their responsiveness to customers [5]; and problem resolution [6]. Therefore, a good understanding of the significance of customer satisfaction is crucial to success in any business organisation. The housebuilding industry is no exception.

This concept of 'customer focus' is an approach that the service industry has been applying for some time, and these customer-oriented attitudes offer lessons for the housebuilding industry. This is a new idea for the industry, but as Normann [7] puts it, companies that used to think of themselves as mere manufacturing firms have to see themselves as service organisations and to accept the consequences of this new view. The step that they should take will be a shift towards a service, and therefore, customer orientation.

In 1998, the Egan report [8] identified key drivers which needed to be addressed if the UK construction industry was to benefit from the radical change experienced in other industries. Whilst these drivers were considered applicable to all sectors of the construction industry, Egan specifically considered the social housebuilding sector as an area where significant improvements in performance could be achieved. In reviewing the housebuilding sector, the potential to lead change in housing via the social housebuilding programme was highlighted, and the Housing Forum was established for this task as a government-funded body. Its objectives included: agreement on targets for improvement and performance indicators, simplification of procurement processes and standardisation of component linkages, encouragement of long-term partnering arrangements. A set of 12 key performance indicators (KPIs) were accordingly identified; one of them was customer satisfaction.

The UK housebuilding industry has long had an image problem, but its difficulties in satisfying its customers are now being exposed to greater public scrutiny than at any other time. The industry has now been put under pressure to make strenuous efforts to modernise itself [9]. Consequently, improving the ‘customer focus’ of the industry has become something of a holy grail for housebuilders [10]. Research conducted so far in the context of housebuilding has indicated that there are gaps between what customers expect and what housebuilders offer in three main areas: the quality of workmanship, service provision, and house design; and these gaps suggest that customers are not satisfied with the products and service provided [11].

In order to bridge such gaps, and consequently to make the customers more satisfied, it is crucial for housing providers to communicate with the customers. Customers’ views must not be neglected and a feedback chain of information should be incorporated into the business process. Feedback from customers, such as comments and complaints, helps the company to know when something goes wrong [12]. Thus, communication has to be dialogue, not monologue: not only does the company talk to customers, but it should also listen to their opinions. This is how the relationship between the company and the customers can be built. This relationship is particularly important in the competitive market. In order to survive the turbulent changes in the market, the company has to develop relationships with end-customers, as well as with suppliers and distributors. As customer requirements influence the market, the feedback from the customers is essential in adapting to changes in the market. Everyone in the business process has to take part in this ‘relationship-marketing’ [13].

In these contexts, a four-year research project began in 2001 to evaluate the social housing sector’s performance [14]. This paper reports on the outcomes of the post-occupancy tenant satisfaction survey that was carried out as part of the project. The present paper deals with two issues: the result of the questionnaire survey, and an analysis of organisational problems that were encountered in conducting the survey.

2. Benchmarking performances

The present research project includes 12 registered social landlords (RSLs; i.e. housing groups/associations) in the UK, which have formed a consortium. The consortium aims to improve the quality in terms of amenity and performance for the residents and to eliminate defects, in line with the government policies and associated initiatives within the industry described above. In order to achieve these, the consortium introduces lean production methods to housebuilding, with the following objectives:

(a) To try out a new construction method (using factory made pre-fabricated timber-frame, as opposed to the traditional brick and block method);

(b) To work on the ‘partnering’ agreement (as opposed to tendering, through which a contractor is traditionally assigned for a project) between the consortium and a particular housebuilder/off-site manufacturer; and consequently,

(c) To achieve higher customer satisfaction.

As part of the research project, a questionnaire survey was designed to investigate the level of satisfaction of tenants who lived in the consortium’s schemes which had been built with the new procurement system. Five themes were identified for the customer satisfaction KPI in the benchmarking workshops held by academic researchers, consultants and the consortium at the beginning of the project. These five themes form the main part of the questionnaire: (1) space and facilities, (2) ventilation, (3) sound insulation, (4) ease of use, and (5) after-care.

The questionnaire also contains questions as to:
(6) general satisfaction to see if participants are basically happy with their homes; and, (7) satisfaction with overall service provision by the landlord and opportunities for participation in decision-making.

These questions are called Best Value questions, set by the Housing Corporation (the funder for RSLs) to be included in any tenant satisfaction surveys.

3. The survey results

The survey was conducted in two stages – in June 2003 and in January and February 2004 – with 3 RSLs and with a total of 8 schemes which reached the end of the 12-month DLP (Defect Liability Period). Ninety-five questionnaires were sent out and 34 were returned (the 35.8 per cent response rate). Seventy-one percent of the participants were female. Forty-four percent were aged between 18 and 35, 21 per cent were between 36 and 50, and the rest were over 50.

3.1. General satisfaction with the home

Participants are satisfied with their homes and generally think that their new homes are better than the last ones (Table 1).

Table 1: General satisfaction with the home

		Frequencies	%
Satisfaction with the home	Very satisfied	18	52.9
	Fairly satisfied	14	41.2
	Neither	1	2.9
	Fairly satisfied	1	2.9
	Very dissatisfied	0	
Compared to the last home	Better than	28	84.8
	Worse than	2	6.1
	No opinion	3	9.1

Disable participants seem to be pleased with the adaptation that the housing provider made for them:

> ‘Being disabled, [I find that] this house has made life a lot easer for me due to the space of rooms, hand railing and a downstairs shower.’

Indeed, more flexible internal design is possible because of the timber-frame method which does not rely on walls to support the weight of the house. The use of this new building method could enhance the flexibility in the internal plan for different users with different needs [15].

3.2. Satisfaction with space and facilities in the home

Questions about satisfaction with space and facilities in the home were asked by using a 1-10 scale (10 = very satisfied and 1 = very dissatisfied). Table 2 shows participants' satisfaction levels with different features in their homes.

Table 2. Satisfaction with space and facilities in the home

	Mean score	**Frequencies of low scores (4 or below)**	**%**
Space in the kitchen	7.12	8	23.5
Kitchen fittings	7.94	5	14.7
Space in the bathroom	8.03	3	8.8
Bathroom fittings	7.65	5	14.7
Space in the living room	7.94	5	14.7
Space in bedrooms	7.94	3	8.8
The no. and location of electrical sockets	8.45	3	9.1
Internal doors	8.06	3	9.1
External doors	7.36	5	15.2
Windows	7.25	7	21.9
Internal storage space	6.33	9	27.3
External storage space	7.29	4	12.9

Participants are generally satisfied with space and facilities in their homes with some exceptions. Typical reasons for dissatisfaction are:

- Lack of storage space (mainly internal, but also external),
- The small size of the kitchen,
- Poor fittings and finishes (doors, windows, door handles, showers, etc.),
- External design and maintenance (landscape, garden, parking, etc.).

These negative comments are valuable. Social housing customers tend to have little choice in their housing situations. In order to avoid false loyalty from the customers, it is important to analyse the customers' negative views. Furthermore, it is useful to analyse the discrepancies between customer expectations and the management's perception of their customers' expectations, and between the managements' perceptions and the translation of those perceptions into specifications. By identifying differences in views, a housebuilder can reduce guess-work and improve value to its customers (Winch et al., 1998).

3.3. Satisfaction with ventilation

Three-quarters of the participants feel warm in their homes on a cold day, and most of them find it easy to keep their homes sufficiently ventilated (Table 3). The typical reasons for disagreement are: draught from doors and windows, and temperature varied within the home. In addition, participants claim that the running costs for their new homes were about the same as they had expected.

Table 3: Perceptions of ventilation

		Frequencies	**%**
Feeling warm on a cold day	Yes	26	78.8
	No	7	21.2
Easy to keep the home ventilated	Yes	32	97.0
	No	1	3.0

3.4. Satisfaction with sound insulation

The majority of the participants say that they are bothered by noise from outside (e.g. traffic and children playing), and about one-third say that they are bothered by noise coming through the wall from next-door neighbours. Noise between rooms and floors, as well as squeaky floors, also appears to be a little problematic, for about 40 per cent of the participants mention that they are bothered by noise within the home (Table 4).

Table 4: Perception of sound insulation

		Frequencies	%
From outside	Often	14	42.4
	Sometimes	11	33.3
	Rarely	6	18.2
	Not at all	2	6.1
From internal communal space (e.g. staircase and corridor)	Often	1	3.3
	Sometimes	2	6.7
	Rarely	4	13.3
	Not at all	13	43.4
	N/A	10	33.3
Through the wall from next-door	Often	6	18.8
	Sometimes	6	18.8
	Rarely	9	28.1
	Not at all	11	34.4
From flats upstairs	Often	3	10.0
	Sometimes	1	3.3
	Rarely	0	
	Not at all	4	13.3
	N/A	22	73.3
From flats downstairs	Often	0	
	Sometimes	2	7.4
	Rarely	0	
	Not at all	6	22.2
	N/A	19	70.4
Between rooms within the home	Often	6	18.8
	Sometimes	8	25.0
	Rarely	3	9.4
	Not at all	14	43.8
	N/A	1	3.1
Between floors within the home	Often	4	13.3
	Sometimes	8	26.7
	Rarely	3	10.0
	Not at all	9	30.0
	N/A	6	20.0
Squeaky floor boards	Often	12	36.4
	Sometimes	4	12.1
	Rarely	5	15.2
	Not at all	10	30.3
	N/A	2	6.1

3.5. Satisfaction with ease of use

With regard to ease of use of the home, although most participants say that it is easy or relatively easy to clean the home, to garden and to use the heating/hot water systems, there are a few who find it difficult to use those systems and to garden (Table 5). There are also some detailed features that participants find inconvenient, such as the location of the hot water and/or central heating switches.

Table 5: Ease of use

		Frequencies	%
Running cost of the home	More than expected	6	20.0
	About the same	21	70.0
	Less than expected	3	10.0
Easy to clean	Easy	27	79.4
	Relatively easy	4	11.8
	Relatively difficult	3	8.8
	Difficult	0	
Easy to garden	Easy	18	56.3
	Relatively easy	11	34.4
	Relatively difficult	0	
	Difficult	3	9.4
Easy to use the heating system	Easy	23	67.6
	Relatively easy	8	23.5
	Relatively difficult	2	5.9
	Difficult	1	2.9
Easy to use the hot water system	Easy	24	70.6
	Relatively easy	8	23.5
	Relatively difficult	1	2.9
	Difficult	1	2.9

3.6. Satisfaction with after-care services

Participants generally give high scores to after-care services (a 1-10 scale; 10 = very satisfied and 1 = very dissatisfied), except to speed of responses to queries (Table 6). As the following comments show, there are some dissatisfied tenants in terms of repair works. When problems are not promptly resolved, the level of dissatisfaction of customers become high [6]. So, this is a warning sign:

§ I have been waiting for a repair work for months. I have phoned twice and supposedly had it logged both times.

§ Any repair works that have been done are broken again.

§ Contractors in some circumstances have been very poor in response time and completion. I had a loose roof tile on my property for two months, which could have blown off and injured someone at any time.

§ [Contractors] don't come out within time, don't knock or ring bell. They put paper in door and walk away. Contractors can be blunt.

Table 6: Perceptions of after-care

	Mean score	Frequencies of low scores (4 and under)	%
Ease of contact with the landlord	8.00	3	9.1
Helpfulness of the staff	7.94	3	9.4
Speed of response to queries	6.76	7	21.2
Information the landlord provides	8.16	3	9.7
The time period repair works carried out	7.28	5	15.6
Contractors' attitudes	7.64	5	15.2
The quality of repair works	7.91	5	15.6

3.7. General satisfaction with services provided by the landlord

Participants are satisfied with overall services provided by their landlord and are not dissatisfied with opportunities for participating in decision making (Table 7).

Table 7. Satisfaction with overall services

		Frequencies	%
Overall services	Very satisfied	17	50.0
	Fairly satisfied	13	38.2
	Neither	3	8.8
	Fairly satisfied	0	
	Very dissatisfied	1	2.9
Opportunities for participation	Very satisfied	9	29.0
	Fairly satisfied	11	35.5
	Neither	5	16.1
	Fairly satisfied	2	6.5
	Very dissatisfied	1	3.2
	No opinion	3	9.7

3.8. Summary

Overall, the participants are satisfied with their homes and the services provided. However, there is more housing providers can do, as residents would like better quality workmanship and design than currently offered. For example, high-quality off-site manufacturing should be able to cope better with quality problems, such as draught and noise. Also, although some attributes and features (e.g. the provision of storage space, the design/location of central heating/hot water switches and the maintenance of the garden) cannot be controlled by off-site manufacturing, they need to be considered in the design stage. In order to improve features that are currently seen as negative in the next generation of design, good communication between customers, housing associations and building contractors is necessary. Also important is the staff's attitudes towards, and attentiveness to, the problems that the residents are facing. Prompt problem resolution is very important to achieve customer satisfaction. People want to feel being looked after by the house provider; and satisfactory 'looking-after' leads to customer satisfaction [11, 17].

4. The management of the survey

There was some difficulty in conducting the tenant survey across the housing associations. In this survey, there were three housing associations involved. ‘A’ Housing Group is based in Kent and consists of several housing associations according to the nature of business. ‘H’ Housing Group, based South East London, has also a number of housing associations according the regions they cover. ‘B’ Housing Association is a single entity, based in Norfolk. Each organisation presented different attitudes towards the survey initiated by the consortium.

In order to understand the nature of the difficulty experienced, informal discussions were carried out with relevant officers in the three RSLs that carried out the tenant satisfaction survey (a meeting and discussions over e-mail with A and H Housing Groups respectively, and a telephone interview with B Housing Association). It then became clear that there was lack of understanding about the aims of the survey and of the consortium by the participating RSLs.

Firstly, the complex organisational structure has turned out to be a problem in this particular survey exercise. The questions to be asked in the questionnaire were agreed by representatives from several RSLs and academic researchers after a number of meetings. However, as A Housing Group has several housing associations under its umbrella, it seemed more difficult for the housing director who had attended the meetings to get consensus on the content of the questionnaire from different sections of his organisation:

> ‘I needed agreement from colleagues before writing to tenants, and they [the colleagues] were seeking to meddle.’ (Housing Director, A Housing Group)

It is understandable that, if a RSL is going to carry out a questionnaire survey, they would also like to include the questions that they want to ask the tenants, as they know that their tenants do not like to receive too many questionnaires. The issue here is that the purpose of this particular survey was not really understood within the housing group in question. The questionnaire survey had a specific aim to find out the tenant satisfaction level in relation to the finished products constructed by the new procurement procedure as well as to the services provision. But this message was not communicated.

B Housing Association, on the other hand, was a straightforward case. The development support officer took full responsibility for carrying out the survey and no one questioned her within the organisation as she had been in charge of all the tenant surveys in the organisation. She understood that it was a decision made by the consortium which her organisation was part of and followed the order, sending out the questionnaire to relevant tenants.

Lastly, There was misunderstanding about the survey procedure, rather than its purpose. The development director instructed some of the agreed questions to be included in their own tenant survey to cover the 5 themes mentioned above. Although the dates for the survey had been agreed between the customer manager who was going to conduct the survey and the project researchers, this misunderstanding delayed the whole exercise for two months:

> I was told that I did not have to conduct your survey. The director said that they had included most of your questions in our satisfaction survey. (Customer Manager, H Housing Group)

These examples show the importance of communication between the consortium and participating RSLs, as well as within the RSL. It is especially difficult to achieve an understanding when an organisation has a complex organisational structure, involving a number of different housing associations that have different issues and agendas. A better understanding of such organisational problems would help a group of RSLs to conduct cross-organisational surveys more efficiently.

Currently, the consortium is withholding its activities. When the consortium originally started, there were 22 RSLs participating, but the number of the member RSLs became 12 by the time this research project started. The reason why it has not worked well is still to be investigated, but the different agendas that the participating RSLs and their internal sections have seem to have contributed to its failure. Furthermore, for those who actually do surveys, there is little difference between their own surveys and the consortium's surveys. The latter is just additional work for them and more surveys for their customers. Unless the idea of being part of the consortium is disseminated and understood within and across the organisational boundaries, even a joint survey appears to be difficult to carry out.

5. Conclusion

This is a small-scale study and the results cannot be generalised. However, it has identified tenants' perceptions of the quality of their homes and of the services provided, indicating some problems. Firstly, regarding the physical quality of the homes, the timber-frame construction method, off-site manufacturing and on-site assembly seem to have succeeded in providing a better building design and quality to some extent. Nonetheless, there are still a few problems to be sorted out (e.g. storage space, draught and sound insulation), which should be taken into consideration in the design of the next generation.

Secondly, on the quality of services, although the satisfaction level is generally high, there is still room to improve. As seen above, customer satisfaction is determined by employees' performance. Customers want attentive responses to their problems. Thus, responsiveness to enquiries and repair works, for example, do affect the way in which customers feel about the service provider and its services.

Lastly, with regard to the management of the survey, it has become clear that there has been lack of understanding about the aims of the survey and of the consortium among the participating RSLs. Furthermore, the importance of communication between the management and the front-line employees who actually carry out the survey has also been shown. These organisational issues need to be taken into account when a similar cross-organisational survey or project is conducted.

An innovative procurement system (i.e. the use of pre-fabricated timber-frame method, and partnering agreement with a single contractor/off-site manufacturer) that this group of housing associations employed, still has room to improve. The above findings – the survey results and the analysis of organisational problems – will be fed back to the consortium, so that the member RSLs can understand their strengths and weaknesses and improve their products and performances. It is also hoped that the findings provide any social housing providers with a lesson to learn in order to achieve higher customer satisfaction and consequently successful business.

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Client Requirements Management in Low-income House Building Projects in Brazil

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Abstract

This paper describes the main results of a multiple case study concerned with client requirements management in the product development process (PDP) of seven low-income house-building projects, carried out in the South of Brazil. These projects were developed in two different forms of Brazilian housing provision: four in the Residential Leasing Program (*Programa de Arrendamento Residencial – PAR*) and three in the first phase of the City Entrance Integrated Program

(*Programa Integrado Entrada da Cidade - PIEC*). Both are new forms of housing provision in Brazil and have created different client relationships, which have never been experienced in Brazil before. The main objective was the comprehension of the PDP of both forms of housing provision as well as the identification of a potential client requirements management in public instances, in order to improve the quality of these products without raising costs. This investigation was based on the analysis of design, production control and legal documents, semi-structured interviews carried out with design and production professionals, as well as the evaluation of user's satisfaction. The main contributions of the study are concerned with the understanding of the relationship between the PDP improvements and the product performance according to the perception of the various clients (users, construction companies, design and budget professionals, financial agents, as well as Municipal and Federal Government professionals) involved in the PDP. The four case studies presented in this paper are part of a larger research project, which is being developed in a network of six Universities in Brazil. The main objective of this larger research project is to propose guidelines for client requirements management in the PDP of low-income house-building projects.

Keywords: Client requirements management, value generation, product development process, low-income house-building projects

1. Client Requirements Management in the Product Development Process

1.1 Overview

The design process can be understood as a sequence of steps and activities that make the construction of a building possible. Design and construction can be analyzed as a product development process (PDP) because it describes the activities needed for the development of a determined product, for example, a building. The main benefit of analyzing design and construction as a PDP is that it gives a more integrated view of the whole process. In manufacturing, the PDP is understood as a sequence of steps or activities necessary for the conception, design and commercialization of a product. According to Ulrich and Eppinger [1], the PDP is a series of activities needed for the conception and design of a product, from the identification of a market opportunity to its delivery for the final client. When compared, the necessary steps for the development of a product in construction and manufacturing, many similar points stand out: the importance of client requirements capture and the translation of these requirements into design specifications [2, 3]; the product is developed by teams of various areas, therefore, there is a considerable variety of people with different abilities and knowledge involved in the process; the main phases of the process are similar, as identifies in the work of Kagioglou et al. [4] and Ulrich & Eppinger [5]; there is a great amount of information, information flow and trade-offs during the process [6, 7]; and many uncertainties in the process.

But many different point are also identified between the development of a product in construction and manufacturing, such as: in manufacturing, a prototype is made during the development o the product's concept [5]; for a building, each productive cycle involves a new piece a land [8], therefore, a new location, what makes a prototyping not as useful as in manufacturing [9]. Among the various types of building, a house building is destined specifically for a basic need: residence. For this reason, the house building is a product that has attributes that commonly generate a more complex consumer behavior, because it is a more expensive product with unique characteristics and considered as a product of long-term use [10]. On the other hand, manufacturing products have a shorter life-term than a building.

For the points that make the development of a construction and manufacturing product similar or different, the analysis of the design and construction processes are here considered in a wider context, which is the PDP. A wider view of the PDP is a necessary prerequisite to systematically consider the needs of the various clients involved in the process.

In the construction industry, due to the long use time of the constructed facilities, the client has no prior expertise [9]. Therefore, the outward orientation should be given more attention, in order to obtain more information from the final client. The expression of the needs of a client in a form that describes the facility that he/she desires involves "processing" to ensure that the information is presented in a format that enhances adequate understanding of what the client desires, and which facilitates their implementation by designers [11].

The systematic management of information on client requirements consists of finding the knowledge applicable to a problem situation and formulating it in project objectives and constraints. The client requirements management consists of the identification, analysis, prioritization and availability of information about the client's necessities and preferences. Such tasks can potentially result in a better definition of possible design solutions, consequently increasing the perceived value by the client. Concurrently, a great challenge for a designer is to define the best solution to meet the client's needs [12].

According to Kalay [13], the need for collaboration arises when the limits of their abilities prevent individuals from completing a given task on their own (due to the lack of knowledge or power), or when collaboration can help them to complete the task more quickly and efficiently. Therefore, the communication is a prerequisite to collaboration, being a means by which the intents, goals and actions of each one of the participants are made known to the other participants in the collaborative effort, thereby forming the basis of their own actions [13]. This poses new demands on communication and cooperation in design practice [14].

The collaborative group must, therefore, establish a definition of the team, identify their outcomes, ensure there is a purpose of the collaboration and clarify the interdependencies of the members [15]. Therefore, collaborative work is not the only mechanism to generate value, but it can make the team more capable of better managing client requirements in the product development process (PDP).

1.2 Low-income house building in Brazil

According to the Brazilian Federal Government's Cities Ministry [16], the Brazilian social debt related to the housing deficit is impressive. Over 7 million families need new homes and over 10 million homes have basic infrastructure problems. The social differences and income concentration, characteristics of the Brazilian society, are manifested physically in the segregated spaces of the cities in the country. In these, the housing needs constitute a greater problem: the lack of decent homes for the poorer citizens represent 91.6% of the total Brazilian housing deficit [16]. Besides being concentrated among the population that has the lowest monthly income, the housing needs are also increasingly concentrated in urban areas.

According to the Fundação João Pinheiro [17], the housing needs include the deficit and housing inadequacy. For this same institution, deficit is understood as the need for the construction of new homes, because of both the replacement and increment of the housing stock. All of these complex housing needs have lead, in the last decades, to a change in the Brazilian Government's role in offering low-income housing. Nowadays, there is greater interaction between public and private sectors. This has lead to growing financial, regulatory, environmental, social and technical complexity, which has made the construction process of low-income house buildings highly decentralized in Brazil. A great number of professionals are involved, resulting in requirement conflicts and in the need to manage trade-offs.

This situation is even graver when it comes to the complete housing provision. The term housing provision is understood as the group of specific actions developed by various governmental and non-governmental agents, that result in one or many types of dwelling units [18]. Moreover, the same authors define complete housing provision as a set of actions, developed by various agents, understood as the supplying of a dwelling unit in an area with urban infrastructure, giving complete inhabitance conditions. Also, the provision of a complete dwelling unit demands the involvement of many agents and created different forms of relationships among them.

The Residential Leasing Program (*Programa de Arrendamento Residencial – PAR*) and the City Entrance Integrated Program (*Programa Integrado Entrada da Cidade – PIEC*) illustrate two representative forms of housing provision in Brazil. They were selected for this research project because they focus on a population with a monthly income that represents the largest part of the Brazilian housing deficit, as shown below in table 1. The PIEC concentrates a population with a family monthly income of zero to three minimum wages and PAR, a population with a family monthly income of three to five minimum wages. The sum of both represents the poorer citizens (91.6%) of the total Brazilian housing deficit, according to the Brazilian Cities Ministry.

Table 1: Brazilian Urban Housing Deficit [17]

Region	**Urban Housing Deficit**	**0-3 Min. wages (%)**	**3-5 Min. wages (%)**	**5-10 Min. wages (%)**	**Over 10 Min. wages (%)**
North	411,600	84.0	7.2	6.9	1.6
Northeast	1,729,100	91.3	5.1	2.1	0.7
Southeast	2,257,500	77.6	11.0	7.1	3.0
South	589,100	80.9	9.4	6.7	2.5
Center-west	427,600	82.9	7.8	6.5	2.0
Brasil	5,414,900	83.2	8.4	5.4	2.0

2. Reserch method

2.1 Overview

This paper describes the main results of a multiple case study concerned with client requirements management in the PDP of seven low-income house-building projects, carried out in the South of Brazil. These studies are part of the Requirements Management and Quality Improvement in

Social Housing (REQUALI)[1] Project, which is still in its early stages. This investigation was based on the analysis of design, production control and legal documents, semi-structured interviews carried out with conception, design, production and financial agency professionals for the PAR and PIEC projects.

For the PAR projects, four house-building projects were analyzed: Alta Vista, Guerreiro, Marcílio Dias and Sul América. The first three are located in the city of Pelotas and the fourth, in Porto Alegre. For the comprehension of the PDP of PAR projects, 8 interviews were carried out with professionals from design and construction companies, as well as from public institutions, such as the Brazilian Public Savings Bank (*Caixa Econômica Federal)*. Other sources of evidence include: evaluation of user's satisfaction in the four PAR projects studied, in which the research team conducted interviews in 20% of the dwelling units, using multiple sources of evidence, such as: open questions (critical incident technique) and closed questions (level of satisfaction), photography and drawing, characterizing this evaluation as predominantly qualitative.

For the PIEC projects, three housing allotments were analyzed: Vila Tecnológica, Pôr-do-Sol and Progresso. All of them are located in the city of Porto Alegre. In order to comprehend the PDP of these projects, 16 interviews were carried out with professionals from various areas and institutions, such as: Brazilian Public Savings Bank, all the eight secretariats that comprehend the Municipal Executive Unit, part of Porto Alegre's City Hall. Other sources of evidence were: designs and reports supplied by the City Hall for the Bank, visits to the informal settlements and new allotments and photographical registers.

2.2 Brief description of two housing programs in Brazil

2.2.1 Residential Leasing Program

The PAR exists in Brazil since 2001 and has been bringing benefits to families with a total monthly income of two to six minimum wages. The program is destined for the construction or refurbishment of buildings in metropolitan areas, capitals and urban centers, with a population of, at least, 100,000 inhabitants. This program is managed by the Cities Ministry of the Federal Government of Brazil and is carried out by the Brazilian Public Savings along with the participation of construction companies, which design and construct these projects. The

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[1] The REQUALI Project started in 2003 and its conclusion is previewed for 2006. It is being carried out by a network of six Brazilian universities in the states of Rio Grande do Sul (Federal University of Rio Grande do Sul, Federal University of Pelotas), Ceará (Federal University of Ceará, Ceará State University), Paraná (Londrina State University) and Bahia (Feira de Santana State University). The main objective of the REQUALI project consists of establishing criteria and directives for client requirements management in low-income house building projects, aiming at the improvement of these projects' quality. The studies are focuses on existing programs in Brazil, such as PAR and PIEC.

Residential Leasing Program (PAR) is one of the most important programs for low-cost housing provision in Brazil. This program is a new form of housing provision and requires innovative roles for both public and private organizations in product development, and a new form of relationship with the final user, which has never been experienced in Brazil before.

It is important to point out that the main client is the Bank, since it plays a major role in the conception of projects. Its technical staff is responsible for establishing the main parameters for the product (cost yardstick, design parameters, criteria for choosing technologies, etc.), design evaluation, final user selection. Moreover, the Bank owns the dwellings for a minimum period of 15 years. The users have an incipient participation in the process, being selected only during the production phase, when the design has already been concluded. This characteristic might cause future conflicts, during the 15-year leasing period, since the Bank prohibits any irreversible change in the dwelling unit. In this sense, it is essential to identify the user's requirements in order to minimize these conflicts and raise the product's value, since they can become the owners after the leasing period.

In the state of Rio Grande do Sul, 58 PAR projects are either already in the use phase or in the production phase. Only in the year of 2004, 3.4 thousand dwellings were built in 11 cities: Bagé, Cachoeirinha, Novo Hamburgo, Parobé, Passo Fundo, Pelotas, Portão, Porto Alegre, Rio Grande, Santa Maria e Sapiranga. Of these 11 cities, two of them stand out: Pelotas (with 12 projects) and Porto Alegre (with 9 projects, including 4 refurbishments). Because these two cities in the state of Rio Grande do Sul present the largest number of PAR projects, they were chosen for the development of this research. Four projects were selected, three in the city of Pelotas (projects Alta Vista, Guerreiro and Marcílio Dias) and one in downtown Porto Alegre (project Sul América).

2.2.2 City Entrance Integrated Program

The City Entrance Integrated Program (*PIEC*), which was started in 2002 in Porto Alegre, in the state of Rio Grande do Sul, has been bringing benefits to families with a total monthly income of zero to three minimum wages. When totally concluded, the PIEC will benefit 3,775 families, who live precariously in 22 informal settlements. In the first phase of PIEC, that has already been concluded, 413 families received new dwellings in three allotments: Vila Tecnológica, Pôr-do-Sol and Progesso.

The PIEC is integrated by four projects: road infrastructure, landscape valorization, housing and social work. Besides the importance of the housing provision, that program also represents the restructuring a significant urban area, especially because of the road system upgrading and environmental recovery. Another difference from that program to PAR is the development of the social work, which aims at the inclusion of those people in the formal city by means of work and income generation, besides community participation in some phases of the development of house building projects.

The program's conception was a complex process that lasted about 6 years. The intervention area is of three neighborhoods in the city of Porto Alegre (Humaitá, Farrapos and Navegantes). The selection of this area was made according to the life quality indicator, which was very low for this area, and the community needs that live in 22 irregular settlements.

Besides, the evolution of the PIEC is linked to demands of the process of the Participatory Budget (*Orçamento Participativo - OP*), which was initiated in the beginning of the 1990s in Porto Alegre. According to Fruet [19] the need to solve urban problems (lack of urban services, secure tenure, transportation, education and health services) has motivated people to organize and adhere to this new space of participation. In this sense, the OP and other mechanisms previewed in the Master Plan, such as the integrated projects and the Special Social Interest Areas, allied to international finance agent's demands and to the experience of the City hall in housing provision, which resulted in a new format for low-income housing provision in Porto Alegre.

PIEC is different than PAR because its main client is the population to be served, aiming at the inclusion of the people who live in the 22 irregular settlements in the formal Porto Alegre. The social project involved, among others, a detailed register and, through the area identification in the city, the City Hall's priority was to serve all of the registered families. Another important client in PIEC is the City Hall itself, because of its involvement in the conception and development of the entire program and in the future management of the settlements.

3. Results of the multiple case study

3.1 Results related to PAR´s case studies

Initially, the product development process for PAR projects was analyzed, with the identification of the main phases, activities, clients, as well as the products that separate each phase in order to better identify problems and opportunities for client requirements management. Four main opportunities for client requirements capture were identified in the process, one in the first phase (concept and design phase), two in the second (production phase) and one in the last phase (use and occupancy phase). They are: initial registration of interested families, selection of registered families, social project and evaluation of user satisfaction. Also, some positive and negative characteristics were identified in this program, in the main phases in with client requirements management can be developed.

3.1.1 Positive and negative characteristics in conception

The product development starts with the search for a terrain, which is analyzed by the Bank's technical staff. The terrains must be located in urban areas, close to services and public transportation. This is one of the main positive characteristics of PAR projects. In the case of the PAR refurbishment, the location is an even greater positive point, because the refurbished buildings are located in city centers. Another important point is that the program is an opportunity for low-income families to obtain their house after the 15-year leasing period, which represents an important asset in a country with a history of unstable economics.

An improvement opportunity identified in the program is that the registered families are only selected after the project has been designed, during the production phase. These families requirements are, therefore, not captured and used in the design process and the construction company, which designs and builds the projects, do not know who they are designing for. Another negative point identified for PAR refurbishments is the environmental and sound pollution existent in city centers, contrasting the fact that these buildings are very well located when it comes to services and public transportation.

3.1.2 Positive and negative characteristics in design

In the design of the common areas, an important point identified is the leisure areas, playground, sports court, community center, with are normally only present in middle-class projects. The families also feel safer in this pleasant environment with 24-hour security guards, which are not common, not even in middle-class condominiums. The dwelling units are small, around 39 m², but are considered better than other dwelling units in the local construction market.

The negative points identified in the design were mainly in the dwelling unit. The users considered the laundry room too small, with no area for hanging and drying clothes. This might be a regional characteristic, since the humidity level is very high in the South of Brazil. The users also pointed out the integration between the kitchen and the living room as a negative point. About 40% already have or wish to separate the kitchen from the living room. In PAR Sul América, about 25% of the dwelling units are studios and most have been vacant for almost three years (the entire use phase). This demonstrates that the Bank did not know who their final client was before the design phase. In PAR Sul América, the lack of open areas for leisure, especially for children, leads to a smaller number of families (29%) with children interested in this project. In the projects in Pelotas (two-bedroom apartments), there are 48.6% of families with children.

3.1.3 Positive and negative characteristics in use

In the use phase, the main positive point identified if the community life that the program makes possible for the families. Most of them did not know what it was like to live in a condominium before, with common leisure areas. Also, because these projects are well located, they loose less time commuting from home to work, therefore having more time to spend with their families and friends.

The main problem is the maintenance of these projects. The Bank contracts a building administration company, which manages the contracts, common areas and dwelling units. This company has created a barrier between the users and the Bank. In some cases, such as in PAR Sul América, the maintenance tax has already equaled the leasing tax, probably because this building has two elevators, with high maintenance cost.

3.2 Results related to PIEC's case study

Initially, the main characteristics of the program were identified, especially the one that points out the differences between this program and other existing Brazilian housing provision programs, especially PAR. In this sense, the main points identified in the PIEC were: extent of the program, integrated program and social project.

3.2.1 Positive and negative characteristics in the program's extent

One of the main characteristics of this program is its extent. The large sum of money invested (55 million dollars) reflects on the number of families that is served. The PIEC represented the first opportunity for a complete register of a large area in the city's urban space. All of the infrastructure conditions were surveyed, as well as a detailed profile of the population in the 22 settlements. Moreover, viability studies were developed for new investments capable of absorbing workers in the region, surveying the companies in the region, identifying their needs. In this sense, the program's extent is a stimulus to partnership among the City Hall and NGOs (non-governmental organizations), universities, associations, public institutions and private initiative.

On the other hand, in relation to the negative characteristics there are many aspects to be considered because of the high complexity of investment of heavy resources that result in: slow conception (around 6 years, according the professionals of the City Hall), difficulties for development and execution, difficulties to control and plan. Another important point is a great contrast between the slow development of a formal housing program and the reality of the life dynamics of registered communities. The families change very quickly, the birth rate is very high and the new necessities grow very fast.

3.2.2 Positive and negative characteristics in the integrated program

In order to make this thorough intervention viable, there is the need to integrate in the City Hall the various secretariats and professionals that participate in the development of a project as big as this one. In search of integration, a multidisciplinary approach was used among secretariats and, especially inside the Municipal Department of Housing (DEMHAB). The need for this integration is explicit by the projects overlapping in the territorial space: infrastructure, road structure, sanitation, housing, work and income generation equipments.

On the other hand, in relation to the negative characteristics there are many aspects to be considered related to alternating program coordination among City Hall secretariats. This results in fragmentation of the process view by professionals involved, late creation of the Municipal Executive Unit and difficulties for attending the priorities of the program and fragmentation in some actions, for example contracting of outside professionals. The program demands a new form of working that breaks the organizational structure of the City Hall leading to difficulties in DEMHAB projects to be approved by another secretariat in the same City Hall.

3.2.3 Positive and negative Characteristics in the Social Project

The social project deserves special highlight in this program because it represents an important opportunity for client requirements management. Besides, it is a project that tries to guarantee an effective social inclusion of the served communities. PIEC was the first program with specific resources for the social project in the city of Porto Alegre. This resulted in the first application of a social-economic register which permitted a more detailed knowledge of the community's reality (income, educational level, activities, relationship with animals, handicapped people).

On the other hand, demands of too many reports by HBB take too much time for the professionals. Also, the requirements of communities were incompletely identified, such as when they opened a computer course, not knowing that most of the population was illiterate. A specific challenge for the communities is changing the people's lives, giving them conditions to maintain themselves in this new life (paying accounts, taxes, living in a condominium, etc). In a few months of use, depredation was already noticed in these condominiums, because they steal community equipments in order to obtain money with their sale. Which demonstrated that the social project is not giving a fast answer to the social problems that this population faces. Also, there is the need to break pathological relationships present in these communities, such as sexual exploitation, slavery, oppression and drug trafficking.

The program is still small if compared to the urban housing deficit in Porto Alegre and the continuous flow of poor people to the capital. But it represents a new trend in Brazilian housing interventions, being more thorough when compared to traditional interventions.

4. Conclusions

The multiple case study for both forms of housing provision indicated that client requirements management must be considered from the initial phases of building projects. There are clear signs of client requirements capture for the PIEC projects during the social project, but these are not well processed during the PDP. On the other hand, in the PAR projects, there is no client requirements capture in the beginning of the process, leading to a design following the logic of mass production, not considering specific requirements of the final clients. The register of the families, carried out during the social project in the PIEC, is an example of client requirements capture that could be used for PAR projects. Nevertheless, the processing must be improved.

Also, a need for a more thorough view of the PDP as well as collaboration between the actors that develop the products and those that inspect them for both forms of housing provision is needed. For the PIEC projects, there should be a more intense collaboration between the Bank and the City Hall. Moreover, for the PAR projects, there should be a more intense information flow between the Bank and the construction companies that develop the products, avoiding re-work.

Among the agents that conceive the programs (the Bank for the PAR projects and the City Hall for the PIEC projects), an improvement opportunity was identified when it comes to the integration among the various sectors in these institutions. In both institutions, because of the traditional fragmented structure, the technicians have difficulty in viewing the entire PDP because they only work in parts of it. The development of an organizational structure that permits and enables conjoint actions can be reached through the use of training and approaches that can help these professionals to view the process as a whole. This integrated view of the processes is a pre-requisite for client requirements management. Besides this, the use of approaches to manage trade-offs and establish communication interfaces, as well as specific training for collaborative work, is needed for client requirements management and, consequently, value generation for the main clients involved in the processes.

Specially related to the communication interfaces, another negative point identified in the public institutions that conceive the products (the Bank and the City Hall) is the lack of integration between the databases and software used by the various sectors. In order to have a more intense information flow, the sectors should be more integrated through an efficient information system.

Finally, another important point in value generation is the participation of the final client in the development process. For the PIEC, there is an intense participation of the final client in the process, from conception phase, through the identification of their demands by the participatory budget. This participation goes through the development of the design, production until the management of use of these projects. On the other hand, in the PAR, the final clients have no effective participation in the process and the families are only selected in the end of the production phase, when the design has already been completed. Therefore, their requirements are not captures in the beginning of the process. The experiences from both forms housing provision could be used in order to improve them both, specially related to client requirements management, with the final objective of raising value from the user’s perspective.

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Section IV

Workplace management

Usable workplaces: action research

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Abstract

Conventional approaches to building performance focus on technical, functional and operational aspect of their use. More recently, building performance appraisal has focused on functionality, serviceability and accessibility in an attempt to assess buildings-in-use. Post occupancy evaluation seeks to relate building performance to the design intentions. However, occupying organisations consider buildings from a different perspective, as workplace settings.

In contrast, usability is one of the most important, but most often neglected, aspects of buildings and workplaces. CIB task group (TG51) was created to apply concepts of usability, commonly used in the fields of IT and engineering, to provide a better understanding of the user experience of buildings and workplaces. Work to apply these concepts in building design, construction, management and use is in its infancy.

The work of the task group proceeds through a programme of action research, comprising an intensive series of case studies and workshops, in association with occupying organisations, to produce research findings within a 'business' timeframe, to satisfy a practice audience, and to identify the scope for further collaboration amongst research partners.

The paper introduces a theoretical framework, identifies key concepts and discusses methodological issues raised by this novel research approach, which aims to generate new knowledge for use in design and management in the built environment. The paper describes the selected cases, from five European countries, presents the results of a series of associated workshops and raises methodological issues arising out of the work. The cases consider the use of particular techniques for usability - community-based planning, design-for-all and facilities management. Final results of the two-year programme of work will be presented at the conference.

The work addresses a mixed audience of practitioners, researchers and academics and highlights the opportunities for collaboration in ‘new knowledge production’.

Keywords: sability, workplaces, appraisal, action research

1. Introduction

Usability is one of the most important, but most often neglected, aspects of building performance. Work to apply these concepts in building design, construction, management and use is in its infancy. A new CIB task group (TG51) has been created to apply concepts of usability, commonly used in the fields of IT and engineering, to provide a better understanding of the user experience of buildings.

The agreed objectives of the task group are:

- to conduct out a series of case studies and associated workshops, involving users, practitioners and researchers in a programme of action research
- to develop concepts of usability for application in practice
- to promote, develop and share methods, processes and techniques for the evaluation of buildings-in-use;

The task group has been formed with the commitment of the following research-based partners:

- Laboratoire Espace de Travail, La Villette, Paris, France
- Norwegian University of Science and Technology (NTNU), Trondheim, Norway
- Chalmers University, Gothenburg, Sweden
- University of Salford, Greater Manchester, UK
- VTT, Transport and Buildings, Helsinki, Finland

Each research-based partner facilitates the involvement of a cluster of ‘industrial partners’, representing different stakeholder perspectives as owners, occupiers and operators of buildings and workplaces.

The work of the task group proceeds through a programme of action research, comprising an intensive series of case studies and associated workshops, in association with occupying organisations, to produce research findings within a 'business' timeframe, to satisfy a practice audience, and to identify the scope for further collaboration amongst research partners.

This paper sets out the aims and objectives of the research, clarifies some of the key terms and concepts and describes the exploratory case study framework that has been created in two preparatory workshops held amongst the research partners. The programme of case studies and workshops that comprise the research will be completed and reported in the next six months and initial findings and conclusions will be available at the congress.

2. Usability

Usability has been described as the 'effectiveness, efficiency and satisfaction with which a specified set of users can achieve a specified set of tasks in a particular environment' (ISO 9241, 1998).

There is a growing body of work on usability in related fields, particularly engineering (Neilson, 1993) and computing and web design (Cooper, 1999). Usability refers to the many aspects of human interaction with a man-made system. The user interface is everywhere where people have to use something: from process control systems to office software, from VCR's to ticket vending machines, from buildings to traffic systems.

User experience encompasses all aspects of the end-user's interaction with an organisation, its services, and its products (and its buildings and workplaces). The first requirement for an exemplary user experience is to meet the exact needs of the customer, without fuss or bother. Next comes simplicity and elegance that produce products that are a joy to own, a joy to use.

User experience goes far beyond giving customers what they say they want, or providing checklist features. In order to achieve high-quality user experience of an organisation, there must be a seamless merging of multiple service disciplines, including engineering, marketing, graphical and industrial design, and interface design.

Successful products have two key characteristics:

Functionality - the product will offer functions and features that users need to complete tasks.
Usability - these features will be used easily and efficiently during task completion.

A product's usability is determined by three key factors:

Effectiveness - whether users can achieve what they want to do with the product.

Efficiency - how long it takes them to achieve it.

Satisfaction - their feelings and attitude towards the product.

Usability means that systems are easy and fast to learn, efficient to use, easy to remember, allow rapid recovery from errors and offer a high degree of satisfaction for the user. Usability means bringing the usage perspective into focus, and facing the user.

A focus on usability can bring many important benefits: improved productivity, innovative designs, reduced risk of costly design errors, shorter development time and effort, high competitiveness and high customer satisfaction! Tools are being developed to represent, measure and evaluate usability and to demonstrate the value and benefits of improvement.

The task group will the share an understanding of the concepts of usability, assess applications in the built environment and evaluate available tools and techniques.

2.1 Usable buildings and workplaces

When these concepts are applied to facilities and buildings, there are important distinctions to be drawn between usability, functionality (International Centre for Facilities, 2003), serviceability (Davis et al, 1993) and accessibility (Travis, 2002).

Functionality has been defined as ‘performing or able to perform a regular function’ and is concerned with the functions and features of the product and has no bearing on whether users are able to use them or not. Increased functionality does not mean improved usability!

Serviceability focuses on 'the capability of a facility to provide a range of performances for which it is designed, used, or required to be used, over time' (International Center for Facilities), usability focuses on user perceptions of the ease and efficiency with which they can use the facility. The concepts can be seen as the 'flip sides of the same coin', serviceability from a supply perspective, usability from a demand perspective. Davis and Szigeti suggest that serviceability combines functionality with quality, which they define as the ‘totality of features and characteristics of a product or service that bear on its ability to satisfy stated and implied needs’.

Accessibility is a key dimension of usability. Travis has clarified the objectives of ‘accessibility’ audits, which concentrate on meeting the needs of disabled customers and a usability audit, to meet the needs of all customers. Travis argues that there is little point having an accessible (website) if it is unusable by both disabled and non-disabled people. By following a customer-centred approach, a usability audit can achieve both goals.

Research into ‘buildings-in-use’ has recognised that 'building users quickly recognise when things they need are absent - usually comfort, health and safety, ease of use and quickness of response when they want to change something. A lot of research and legislative effort goes into the first three, but much less for the last two - the essence of usability.' (Leaman, 2000)

Usability was however identified as a key concept in Facilities Management in the first issue of the International Journal of Facilities Management (Alexander, 1997).

Kernoghan et al (1997) used the development of guidance on building access and usability to describe well developed techniques for building evaluation. They suggested practical difficulties for structuring knowledge databases and address ways of making best use of hard won feedback. They presented facilities management as a dynamic process, requiring a dialogue between building providers and users, and building quality as a matter of ongoing negotiation.

The key role of facilities managers is to allow such negotiations to operate both openly and effectively.

Beech (1997) developed the theme of usability in the context of a 'virtual organisation', Reuters. He argued for enhanced teamwork and a more supportive style of leadership. The focus was on organisational culture - the artifacts, values, basic assumptions and normative practices which underlie organisational life. The new approach requires a non-hierarchical, non-judgemental team-working ethos, and a reward system that promotes collaborative working at all levels.

The task group will continue to explore the theoretical underpinning of usability concepts in an action learning approach that ensures practical relevance and applicability.

2.2 Changing the perspective

Applying the concept of usability implies a change from the traditional construction and property perspectives, which focus on the building as a project and a product, and consider technical and functional aspects of performance.

A clear example of these different perspectives is provided by the contrast and focus of the work in two separate centres of excellence at the Building Research Establishment in the United Kingdom, each with an interest in Facilities Management.

On the one hand, the Centre for Whole Life Performance focuses on the built asset and considers'the various issues surrounding facilities management, risk assessment, residual life assessment, functional performance and obsolescence - to ensure best value is achieved for a built asset'.

In contrast, the Centre for Productive Workplace focus on issues involved in evaluating the productive workplace, which cross a number of disciplines - engineers, architects and psychologists. This Centre offers help to organisations to 'get the most out of your workforce by an evaluation of the environmental and organisational aspects of workplace design and operation'.

In both cases the focus is on the capability of the building as an asset and it functional performance without direct reference to the end user. The working group on Usability seeks to redress this imbalance by promoting independent post-occupancy studies, with the direct involvement of users, and the management of feedback and feedforward.

2.3 Buildings as a factor of production

There is now much greater recognition of the need to consider buildings in the context of business, and from the perspective of end users. Buildings are a means to an organisational end and an instrument of use.

The workplace concept is used broadly to relate considerations of the physical setting in which work happens, to the services that support people in those settings and, perhaps most critically, the management processes that enable their effective use. These relationships need to be considered in the context of particular organisational contexts (culture) through cycles of time. The concept also embodies many types of work activity, not only the administrative and clerical work conventionally found in offices, but also health-care, education and industrial production, in a variety of settings and in dispersed locations.

There is considerable interest in the United Kingdom in establishing the links between the quality of the environment, health and well-being and productivity in the workplace. A number of practice-based research groups, eg Office Productivity Network, Workplace Forum, and Building Use Studies, are actively engaged in studies of buildings in use. The BRE has established a Centre for the Productive Workplace.

Similar work is also being undertaken in other European centres, including the Norwegian Building Research Institute, TU Delft, and Chalmers University and, in the United States, at Comell University and MIT.

Perhaps the best example from practice is provided by the work of Leaman and Building Use Studies. The aim is to 'help improve buildings, with hindsight from studies of past performance and foresight from well-considered strategies using simple but powerful tools to get useful results quickly'.

Building-in-use studies have created a usable buildings web-site as a resource for practitioners, managers, building owners, developers, students and anyone else who wants to make buildings more suitable for the people who use them, less damaging to the natural environment and a better long-term investment.

The task group will seek to identify and assimilate related research and to evaluate its application to case examples, in discussion with the industrial partners.

3. Research programme

The background provides a conceptual basis for developing and applying Usability concepts, but a concerted programme of activity is required to test their robustness and applicability in the context of organisations.

The programme of work for the CIB Task Group focuses on studies of the user experience of buildings and research on buildings-in-use and on the workplace, rather than on laboratory or theoretical studies, and will focus on concepts of usability and manageability.

The overall objective is to seek to improve buildings and workplaces through a better understanding of their performance in use, and more care with their design, construction and management. The working group will promote independent workplace appraisals and the management of feedback and feedforward and make the findings generally available where possible.

The task group has a limited two-year life, during which each research-based partner will host a workshop, involving all research-based and industrial partners, to present and discuss a usability case study.

4. Methodology

The project adapts and develops a methodology previously used in an EU research project entitled Workspace (EuroFM, 2000), by working through a series of interactive ‘best practice’ workshops to consider the results of case studies of buildings-in-use. The workshops involve the participation of organisations, organised as clusters of ‘stakeholders’ to represent the interests of owners, occupiers and operators of buildings. The clusters are organised as action learning sets, providing the opportunity to share learning and experience in the business context of the case study organisations.

The overall project uses a multiple case study approach. An initial set of four case studies will be carried out to test the adequacy of the framework, survey methods and to identify the overriding issues, which are of concern to different stakeholders. Material for the main case studies will then be gathered through interviews and analysis of documentation at different levels in each of the organisations involved. The data was being assessed at the level of holistic cases (projects), embedded cases (incidents within projects) and through cross-case comparisons at both of these levels.

A descriptive model will be developed for considering usability in the context of facilities management and business performance. Individual cases to be analysed using a standard framework to include:

- overall assessment of the usability of the workplace;
- assessment of the extent to which original business objectives have been met;
- assessment of changes to the business objectives, adaptation of the workplace;
- identification of the processes through which business objectives were translated into user requirements and usability criteria;
- comparison of design intentions and assumptions with the way buildings are being used;

The case studies focus on the processes by which the client organisation translates business objectives into process and operational performance requirements for the building, during the briefing development, commissioning and occupancy stages of a building. Initial business objectives, assumptions and design intentions will be compared with the buildings-in-use study. Evidence of changing business requirements, the consequences for usability and building performance, and resulting adaptation of the building will be collated to provide a longitudinal study of each case, and provide feedback to all stakeholders.

A 'best practice' workshop will be held in each host organisation to evaluate the cases and to draw out lessons and conclusions.

5. Case Studies

A usability case study framework has been devised, for the purposes of the research, comprising six inter-related dimensions of an organisational system and describing the context of the case study organisation in its business environment and the relationships amongst people, processes and settings, through time. The case study framework has also been related to an assessment for business excellence, the EFQM model, to facilitate discussion with business leaders and managers in the host organisations. The case study framework will be further developed during the project.

Three case studies have been selected and are being prepared, one each in the United Kingdom, Sweden and Finland and a fourth is planned in Norway. All four case studies and associated workshops will be completed in the initial programme of work to be completed by May 2003.

The UK case study focuses on the development of R & D facilities for NCR in Dundee, Scotland. Contribution to the Usability Task Group is demonstrated through the use of novel planning processes. Features of the project include the relocation and change process in such a tight timescale, Community Based Planning process, integration of Business Unit and Facilities Management as well as NCR 'Discovery Centre' being selected as one of the World Class FM practices.

Örebro University Hospital has been chosen as the Swedish case study and focuses on the users experience of functionality and usability of the surgery centre, built 1997, at Örebro University Hospital. Contribution to the Usability Task Group is demonstrated through the analysis of the planning process, the effects of incorporating new technology and new work processes as well analysis of the building configuration/layout. The case also enables a discussion on ongoing development of hospital work and its relationships to clients and premises.

The Finnish case study takes place in the area of Turku Science Park, which is the core of the innovative environment in Southwest Finland. In this area 'Old Mill' offers companies versatile services as well as functional and interesting premises with an atmosphere reminiscent of an old factory. There is a need to enlarge the functional and Old Mill 2 is in a planning phase. The case- study in Old Mill goals firstly to understand the elements of usability in refurbished environment and secondly to produce the elements for the use of planning process of Old Mill 2. The method used is a workplace survey for users of the building and database information about the requirements of the building. This data is analysed in order to find out the relevant components of usability.

The workshops provide the opportunity for participants to share their experience and for the presentation of similar cases. Other workshops are planned in Norway and later in France.

6. Usability processes

A particular focus of the case studies will be the processes by which the organisations ensure improved effectiveness and how successfully they manage organisational change associated with the workplace. These processes include usability planning, design and management and processes of workplace appraisal and audit.

The workshops will provide the opportunity of evaluating the application of particular processes and systems and tools for usability. Processes will include for example community-based planning (ref), universal design (Center for Universal Design, 1997), and particular tools for performance measurement, such as design quality indicators (Gann, 2003).

These tools will be assessed in the context of the organisations, from a facilities management perspective, with a particular interest in the manageability of the workplace (Alexander and Murphy, 1993).

7. New knowledge production

The task group will also reflect on the working of the task group, with particular attention to team working and collaboration.

Cooper (2002) has considered similar collaborative projects as examples of the ‘new production of knowledge’. He describes such production as ‘short-life inter-disciplinary teams collaborate by engaging in a dynamic form of research characterised by practical problem solving through negotiated and consensually produced knowledge.’

New knowledge production increasingly transcends discipline boundaries (Nowotny et al, 2001, Cooper, 2002). New means of knowledge production, mediated electronically over the Internet (Mansell et al., 1998; Cooper, 2002), will be able to unify the cross-disciplinary boundaries working in dispersed locations. Network based collaboration gives organisations the opportunity to share knowledge and hence allows the partners’ cooperation and team approaches to problem solving more quickly (Rifkin, 2000).

8. Conclusions

The results of the four case studies, reports of the associated workshops, and initial findings and conclusions will be presented at the congress. Key issues will be highlighted to generate an initial discussion about the application of usability concepts and techniques to assessing buildings and workplaces in use.

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Workplace planning and target costing techniques in project and facility management

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ABSTRACT

This paper presents a project management concept for programming and designing workplaces in relation to facility user's strategy and operations. The concept includes the target costing product model that defines the life cycle costs basing on spaces needed and workplace planning product model which links spaces to business operations. They enable the definition and costing of working environment in client activity level.

The strategic management of the organization investing in the spatial facilities expect that the investment will support the business idea. The facility user's require working environment with such performances that enables their operations. During programming the building as a solid object can not be predicted; the user activities, extent, mass and materials of the building are unknown. Problem is complex and inductive since there are several correct answers.

Initial information are the values of the customer; "what are the valuable activities for the strategy?", "do they require spatial resources?". Design deals with connections of activities, theme and mass with which the building is connected to built environment. Combining those orthogonal variables in decision making cause more iterations and can be called unnecessary complexity. When dealing with orthogonal, complex and temporally hierarchical information, the information flow in decision making should be one-way. Unnecessary complexity would be reduced if the valuable activities for strategy are defined first, the performances of the working environment for those activities are determined then and the design solutions are looked for after these decisions.

However, some information that is realized in construction–in-site would be crucially needed in programming, namely the life cycle costs that will be caused by decisions. When deciding whether an activity would deserve spatial investment, it would be worth to know if the activity can afford it. Power must be linked to accountability. Target costing principles such as define functional criteria, determine target cost, design to the targets fit perfectly to construction. But the methodologies from the client needs to target cost must then be solved.

Keywords: Project management, knowledge management, workplace planning, target costing, customer needs

1. Target costing in Finnish construction

In the 1980's in Finnish construction sector facility owners thought that there was a lack of concern for their needs on the part of architects and project managers. Building costs seemed to be out of control, unpredictable in relation to their functional needs. Yrjänä Haahtela was working in the National Board of Building, and he was in charge of developing cost economics theory for building construction projects. It was explored that the variance of building costs was big and it was caused by complex set of variables: functional requirements, conditions in site, fluctuations, regional factors and design solutions. The way the design solutions affected to final costs seemed to be partly random. The questions for further research were: "Is it possible to separate those variables in a practical steering model ?", "Is it possible to set a cost target for a building project basing in client's functional needs?", "Is it possible to steer the design solution to the target?" , "How does target costing and steering the design affect to architectural quality?". Haahtela published the theory of target costing for construction in 1980 [1]. In this theory the target cost is set by using the room program (list of rooms) the client requires. The practical method fir target costing and steering the design was published next year. In the 1990's it was completed also to use room performances as initial information. Target costing has been in use for two decades and he benefits of method has been proved indisputable.

In the 1990's Ari Pennanen of Haahtela Research group started to construct a theory to link the need of rooms to the client activities and client business strategy. In this research it became evident that but the geometrics of the functions, also temporal strains of the functions and operation degrees of the rooms are important variables. The conclusion was that client functions and temporal planning of the functions are possible to steer, and this steering process will produce the needed rooms and stakeholders commitment to the result. The theory was named "the theory of workplace planning" and it was published in 2004 [2].

At the moment the research is continued to combine Target Costing and Workplace Planning theories to enable activity based costing management, to trace life cycle costs of the spaces to the user activities.

2. Target costing in other references

Target costing has been in use in Japanese automotive industry since the 1960's. Target costing aims to influence to the product costs (investment costs or life cycle costs) during the design phase by cost planning and cost control. As conventional product development practice converts costs into design outcome, target costing prices rather the design criterion. Since target cost is set before design solution, the price is usually driven by the market [3], i.e. the price is for specified product functionality, which is determined from understanding the needs of the customer and the willingness of the customer to pay for each function. After the product is designed, estimated costs of production are compared with target cost. If the estimated costs are higher than target cost, cost planning is employed to help achieve the target; the Cardinal Rule of target costing is: "The target cost must never be exceeded" [3].

In the 1960's target costing aimed to reducing cost through continuous improvement, "cost kaizen". This is becoming relatively less important in automotive industry, because the efforts made throughout the company will inevitably lead to fewer opportunities to cut costs [4].

According to the study of seven Japanese companies, the target costing discipline has been structured into three sections [3].

- the company's long-term sales and profits objectives in current market conditions
- product level target costing
- to component level target costing, i.e. decomposing product level target to the major functions or subassemblies

3. Target costing suitability to construction

3.1 Needs of the client

The strategic management of the organization investing in the spatial facilities expect that the investment will support the business idea. The facility user's require functional environment with such performances that enables their operations. The client need should be derived from the customers business strategy and the customers operational requirements. There are numerous stakeholders and decision makers in building process. Therefore, in the initial stage of programming, there are a lot of specifications and wishes. Most of them can be considered "right" or "entitled to", many of them are in contradiction to each other and, when combined, they are generally in serious competition for the resources available. Programming is a complex system [2].

3.2 Functional criteria information versus design information

Information used in the programming deals with the values of the customer; "what are the valuable activities for the strategy?", "do the activity require spatial resources?", "does that spatial investment support the strategy?". During programming the building as a physical object can not be predicted. The activities that require spaces, extent of building and materials are unknown. Design deals with connections between needed activities and theme and mass of the building that connects it to the environment. Before construction-in-site the materials, equipment and details will be determined by design (of course, parts of building can be designed after construction has begun, but all the components are designed before their production).

If a problem "do we need to invest in an activity?" is dealt simultaneously with a question "where would it be located in a plan?", there are limitless possible alternatives. If we first answer "no" to the first question, there are no alternatives left. Does answer to question A: "Where will it be in a plan?" create more valuable information to the question B: "Do we need it?" It will not as the problem B is linked to business strategy and problem A to steering the design process. Combining orthogonal variables in decision making cause more iterations and can be called unnecessary complexity [2]. Both programming and design last long, months or years, and unnecessary complexity leads to loss of money and time and offers very little benefits. Design problems should not be mixed with programming problems, one should not seek for a solution while defining the needs. Differentiating needs definition from the design solution is supported also in Suh's axiomatic design concept. It states that good planning require reduction of information content. Therefore customer needs and functional requirements must be determined in a solution-neutral environment [5].

Target costing principles such as:

- define functional criteria
- determine target cost
- design to the targets

fit perfectly to construction. But the methodologies from the client needs to target cost must be solved.

4. Target costing criteria and construction

4.1 Client criteria in construction

In automotive production target costing is often used as a tool between manufacturer and its supplier (external or internal). The manufacturer defines the functional criteria and willingness to pay, supplier designs the product below the target price to ensure the profit. The product criteria can usually be described in measurable way, e.g. the engine must have certain dimensions, power, fuel consumption etc. In construction, when operating in component level target costing, similarities with automotive industry can be found, e.g. main switchboard must have certain dimensions, power, ability to distribution and air exhaust apparatus has to provide certain amount of air, it must heat, cool and filter the air etc.

When operating in product level target costing, when the whole building is a product, conversation with client can not be done with traditional construction language. The client do not want cooling beams, switchboard or columns. Instead the client may want a library for 15 000 volumes and good internal climate in rush hours. The buildings tend to be unique. If we name a building as “an office building”, we don’t know whether they park cars, make food, have conferences, have a library or do fitness exercise in a building. Client functionality description is a complex problem.

In construction there also are soft values that can not be described in measurable way. The building must “hath three conditions: firmness, commodity, and delight” as Vitruvius expressed.

4.2 Quantitative criteria and target costing

In construction most of the functional criteria can be described in measurable way. The customer needs can be defined as a path from customer activity need to workplace spatial needs and finally to performance requirement description like in following example [1,2]:

- customer activity needs: library for 15 000 volumes
- workplace spatial needs: shelving areas 125 m2, pc:s for inquiry 12 m2…
- performance requirement needs internal temperature within +- 2 degrees, load 10 kN/m2…

The target costing techniques to price quantitative functional values by market information can be solved as it will be shown later in this paper.

4.3 Non-quantitative criteria and target costing

There are soft values (e.g. beauty) that can not be controlled in a quantitative way. The non-quantitative values of building, such as pleasantness, beauty, etc. are culturally bound and evolution is essential to culture. People mirror concepts of beauty against their cultural background (their experience, reading, learning. etc.). The basis of European’s taste in music is in accordance with western cultural heritage, interval division and chord techniques. Cultural heritage makes it difficult for an European to find Arabic, Chinese or Indian music beautiful, even though this music, like western music, includes its own culturally specific notions of beauty. Personal judgments of beauty are in accordance with personal inclinations and levels of education. The media (the press, television etc.) usually concentrate on those areas, where the values of individuals concur (how beauty is generally conceptualized) [2].

Culture and pleasantness is a problematic combination, because cultural heritage is cumulative and changes over time. Impressionism in the arts at the end of the 19th century was for the most part considered incomprehensible by both critics and collectors, whereas currently both Monet and Renoir are widely regarded as masters. Many of the buildings currently regarded as beautiful (for example functionalistic) were once beautiful only to a small elite. On the other hand most of the buildings that are currently considered ugly, will, in the future, still be considered ugly, and we do not know the direction evolution will take. The Museum of Modern Arts in Helsinki by Steven Holl delighted many when it was finished, but at the same time many felt it ran counter to modern cultural evolution. Only time will tell if it will become part of the accepted cultural stratum [2] (14.9.2003 The museum of modern arts was voted one of the ten most remarkable buildings in Finland. It was also voted the most unattractive building. The poll was conducted by the Helsingin Sanomat newspaper).

How does target costing deal with soft values? To answer that question we have to find out what is the correlation of architectural quality and costs. Architect Niukkanen has studied the correlation of architectural quality and building costs [6]. The population of the study was design & build competitions in Helsinki City residential building production. The competitors competed with architectural design solutions and price tenders. The architectural quality (external beauty, internal comfort, habitability) was analyzed by a delphi-group and value analyze matrix. The result of the study can be seen in figure 1.

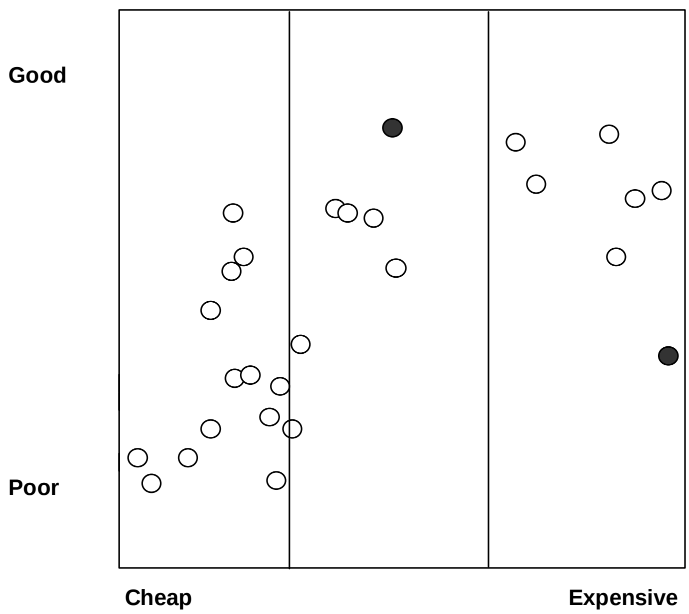

Figure 1: Architectural quality and building costs

If we aim at a minimum price, it might lead to poor quality. But very soon when moving to average price production, the correlation between quality and costs disappears. The most expensive design solution was quite poor in terms of quality and the best quality was achieved with a reasonable price (of course, high price did not prevent good quality). When moving from minimum to reasonable costs the architectural quality can not be assured by allocating more money to production, indeed, this may just as well lead to a poor quality solution as a high quality one. It seems that architectural quality is linked to creativity and artistry of the design group in interpreting our culture and it's changes rather than to money [2]. If we operate within reasonable cost area the building cost don't affect to architectural quality and information from possible future design solutions is not necessary to pay regard to in programming.

If we have methodologies to set the target cost by using quantitative criteria and set target cost in a reasonable area, then the costs can be considered as a fixed variable (a criteria among the others) and the architectural quality is the variable that is managed.

5. Target costing management and project management in construction

In simple "manufacturer and its subcontractor" situation the target cost is defined by market and by target profit. If negotiations are successful, agreement can be done and subcontractor starts design. This also can be done in component level target costing in construction. But acting in this way with "client – contractor" relationship is quite seldom in Europe. Because the client needs are complex and because there are soft values in design, the client don't normally want to lose his power in programming and design. The concern is that the contractor would add his profit by giving up the values that can not be described in measurable way. It is normal in Europe that programming and design is carried out by client's consultant.

Instead of observing customer – supplier relationship, target costing has been used in Finland to make project management more effective by observing internal customer relationships in production. The rest of the production can be considered as a customer of the programming process. The next internal customer would be design. Vague requirements of the stakeholders harm design (and production) [2]. By target costing the client can test fast several requirement combinations and finally commit to one specification and one target cost. It is design's duty then to achieve requirements and target cost. Target costing management is very widely used technique of project management to handle client – design relationship in Finland.

In Japanese automotive industry target costing has been used to reducing cost through continuous improvement. As it can be seen in figure 1, there is potential to cut costs in construction. But total effectiveness in reducing costs might lead to poor architectural quality. Target costing can also be used to prevent expensive solutions and to ensure resources to the best quality.

6. Target Costing Application

Target costing management require reliable methodologies to describe customer needs and to price customer needs. The methodologies must be descriptive in customer language and tested with market information. The Target Costing Application [1] has been developed in Haahtela Group project management. At the moment it is widely used among project managers, contractors and facility owners in Finland. The Target Costing Application calculates the life cycle costs of a project based on the rooms and the requirements for those rooms. The Target Costing Application is a mathematical model that creates the link between the requirements the client sets on the rooms and the possible distribution of elements + use of resources connected to running costs (energy, cleaning…). The budget can then be addressed back to the activities by tracing paths back in the Workplace Planning Procedure.

Target costing must be based in market information, not design information [1,3]. It is easy in component-level target pricing (e.g. air exhaust apparatus) but somewhat difficult in product-level as the buildings tend to be unique and complex in regard to client needs. Suh’s Axiomatic Design concept [5] states an axiom: “A good design is made up of design parameters that result in the independence of the functional requirements from each other”. It means that unnecessary complexity can be reduced if each design components satisfy only one functional requirement. Let’s have a look at two requirements for internal climate: CO2 content and air cooling. They both can be controlled by

- variable air volume system (VAV) or
- CO2 content can be handled by constant air volume (CAV) system and the air temperature by water circulation system and cooling beams.

Suh’s axiom argues that latter solution reduces complexity of whole system. Haahtela’s Target Costing Application have similarities to Suh’s axiom. It is modeled to link one widely used design solution, “reference solution”, for each client requirement, as far as possible. By that means it has been possible to price each requirement by market information. This kind of modeling can describe the cost differences between the client requirements, but not the cost level as whole. It is hard to describe the entity by means of little pieces and on the other hand, the contractor’s tenders are influenced, but by the costs of components, also by their current situation in the markets. Therefore Target Costing Application used also black box modeling [9]: differences between the client requirements are modeled by reference solutions, the level of target cost is calibrated by comparing continuously the modeled result to the actualized tenders. If these two results act regular, the difference is stored in black box. If not, model has to be improved.

■ TOTAL RENT ON ROOM SCHEDULE

Sec.	User	RoomN	Function area	m2	Capital (8%) €/m²/a	Maintenance €/m²/a	Total rent €/m²/a
A			Clinical treatment	60	126	86	286
A			Operating theatre	35	306	261	861
A			Martins room	15	93	43	143
A			Car parking hall	3 000	27	7	42

Figure 2 : Sample of output data of life cycle costs, expressed as a rent of a room.

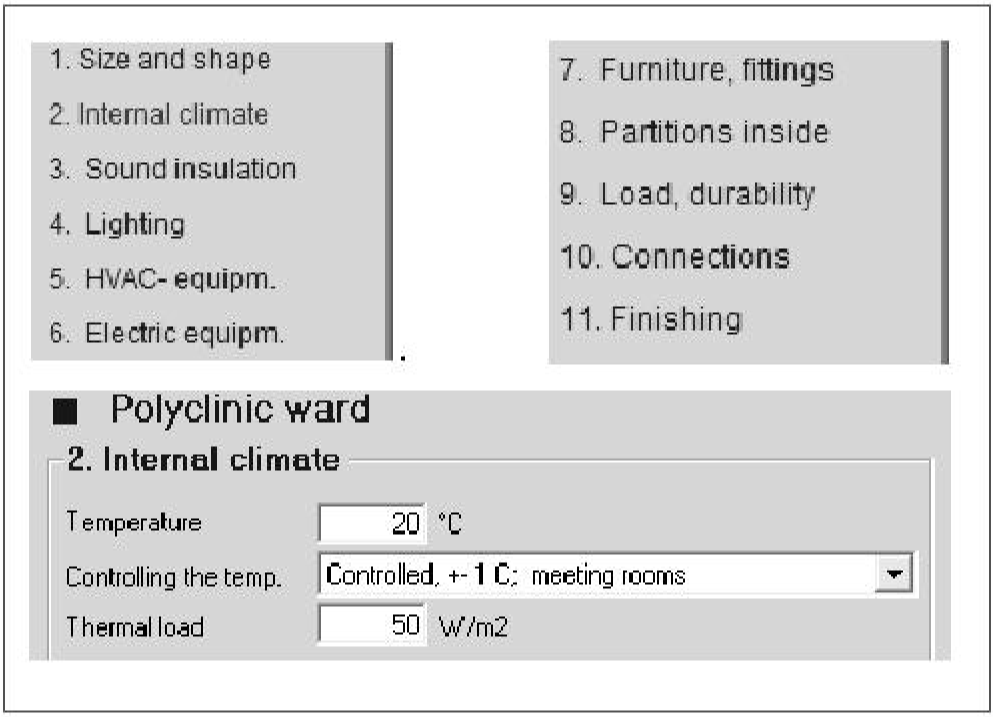

Figure 3: Classification of criteria of the application and sample criteria for internal climate.

7. Workplace planning application

Workplace Planning Application is based on the Workplace Planning concept that was developed in Haahtela Group project management in the 1990's [2]. The concept uses TFV- production theories [7] and ABC –management concepts [8] to construct a workplace planning theory. The Concept of Workplace Planning links workplace production to client's production. A spatial investment in an operation competes for the same recourses as the other investments in the operations. Workplace planning brings spatial investments and the values of the spaces into line with the other factors of client's production. Workplace planning is a process where valuable requirements for workplace production are determined through observing and evaluating the values of stakeholders against the organization's strategy.

The size of a space is determined by the operations taking place within that space (working at table, sleeping, teaching, playing tennis…). Spaces are a scene of temporal flow of operations and non-use time. The number of spaces is determined by the temporal utilization of the spaces. The concept of workplace planning defines value adding spatial investment (or here: no-value-adding) as follows:

- Investment to the operations' time is value adding and the non-use time is non-value adding with regard to the strategy
- Spatial investments in operations that are not needed for the organization's strategy are not value-adding.

The Workplace Planning application describes spatial environment:

- for strategic management as activities that require spatial resources
- for operative management as working environment for operations

Application computes the spatial need and their temporal utilization degrees basing on the factors shown in the table 1.

As the application uses only client activity information as initial input, and the spaces and utilization degrees are the outcome, the project manager knows who or what activities use a certain space, why they use, why it is that size and is there temporal resources left in a space. This information enables Activity Based Costing, if the costs of the spaces are known (previous chapter: target costing application). The application is continuously tested in market. Performance results are tested, but against reference books, against reference buildings. Outcome utilization degrees are tested by post occupancy evaluation. Space lists are tested to already made buildings.

Table 1. Space Quantification Example

Quantification Factor	Description	Example of Education Institution
The total volume of the sector.	No. of Customers or Products.	Two hundred design students.
The activity bill programmed for the sector.	Core Activities Supporting Activities	Teaching & Research. Administrative activities. Dining.
The temporal strain of functions and goals for the use of time in the space i.e. utilization degree.	Temporal Strain. Operating Degree.	Teaching Design Theory 4 credits, 30 h/ credit equals 120 h temporal strain/ student during 3 years. Facility management sets a 75 % utilization degree target for learning environment spaces.
The people working and the geometrics of the objects to be placed in the space.	Each function requires space expressed as a performance result.	Lecturing requires 10sq. Meters of lecture area. Students require standard seating and 1,2 sq. meter workspace. Material shelving require…
Regulations.	Regulatory society defines the quantification of space.	A basketball court have certain dimensions

Workplace planning operates in a complex area. It does not aim for an optimum because an optimum does not exist in a complex system. There are numerous working environment solutions that can be considered acceptable. It aims for a "good" solution. Once the workplace planner has presented the workplace measurements, the facility owner develops an understanding of the present or desired state of the system; i.e., what kind of working environment the owner groups need and value, and what the subsequent consequences will be to their resources. The information presentation allows transparency in that the client stakeholder can trace organizational activities to their origin.

If waste of space for unneeded operations and waste of non-use-time can be reduced, more resources will be available to the other investments for operations, spatial or non-spatial. Seeking for alternatives in value generation is an allocation process. Allocation deal with the questions

- can activities be combined within the same environment?
- is the activity really needed ? Compared to the others ? Are other activities needed ?

What is the criteria that differentiates the chosen solution from the bad ones and from the other good ones? It is the commitment of the participants to something achieved. The product of workplace planning for the rest of production is the stakeholders commitment. Indeed, stakeholders' commitment to the common values and requirements is an absolute necessity in all production to enable value generation. Thus it is a crucial part of the production.

8. Conclusions

Target costing and Workplace planning applications have been made to clarify and intensify internal customer relationship management, particularly between programming and designing. Target costing application enables pricing the rooms needed. Workplace planning application enables the definition of needed rooms on the basis of client activities. When combined, the enable target costing in client activity level.

Target costing application has been widely in use for two decades. It has been proved that it is possible to price the requirements the client sets on the room before design, and it is possible to steer the design to targets.

Workplace Planning application combined with Target Costing has been in use for five years, and the results have been encouraging. In recent cases the building costs have been reduced during the process without losing important activities. In Cygneaeus high school case and Jyväskylä Polytechnics case the "traditional programming" had already been done when the customer asked for workplace planning process. In both cases costs were reduced more than 15 %, decisions were made both by operative and strategic management and stakeholders committed to the result. In Cygnaeus case the process led to so low costs that operative management could add spatial investments. They did not add anything that was removed during the process; discovered waste remained waste. Both the cases has been designed to the targets [2].

Workplace planning and target costing have been used to wide range of lines of business; offices, hospitals, churches, assembly halls, universities, day care centres etc. The concepts have been universal. Better understanding of client values and costing them have not prevented good architectural quality as it has been shown in Synapsia- rehabilitation centre case [2]. The building was named "one of the best pieces of Finnish architecture during 1998…2002" [10]. It is possible to deal with values, money and activities during workplace planning and target costing and to create the best architectural quality

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Usability Walkthrough in Workplaces – What, how, why and when?

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Abstract

The usability of workplaces is a challenge – how then does one investigate it? Usability walkthrough as a method in general can be cognitive or pluralistic. Cognitive walkthrough is a task oriented usability inspection method. Cognitive walkthrough is based on a theory of learning by exploration according to which users try to infer what to do next using cues that the system provides. Pluralistic usability walk through is a method, which combines elements from a usability test and usability inspection.

This paper concentrates on the usability walkthrough methods in the context of a workplace as a system. A pluralistic usability walk-through session involves participants from three groups: group of users representatives, architects and usability professionals from facilities management. Together the participants gather information about the workplace usability by inspecting it. At the end of the session the whole group discusses the findings they have made. The application of cognitive walkthrough is also significant for development and evaluation of workplaces – there exist many components, which are relevant to test from the perspective of continuous learning. The technique is suggested as a tool for a process to evaluate workplaces, identify the gaps between the original design concepts and the current use, and to provide a platform for different parties to communicate.

The paper presents a case study from the business park for IT-companies in Finland. The process of usability walkthrough is described and conclusions include the proposal for developing the method further.

Keywords: usability walkthrough, workplace, usability profile

1. Introduction

The easy use of workplace is one of the main tasks for customer-orientated facilities management. The user of the workplace and his or her experience differ from the experiences of designers, architects and construction teams. There is no use to ignore this diversity but however there is an interesting challenge to develop ways to get benefit out of this diversity. This multidisciplinary approach in practice might be difficult to achieve but it this effort is worth to do.

There are challenges in the method and processes of usability walkthrough and one of them is the shared language and common understanding. The understanding of customer's or end-user's need sounds like different languages even though the focus is on the same object, workplace. The second challenge is the timing in the building process. The third challenge is: who is finally responsible of the usability?

These challenges have been a matter of interest in the research project of Usability of Workplaces. The Usability of Workplaces as a research project of CIB51 Task group includes five different case studies in five countries: England, Sweden, France, Norway and Finland. The Finnish case study focused on the elements of usability in a refurbished working environment of Old Mill Business Park. The Old Mill is located in Turku Science Park area and offers services as well as premises with an atmosphere of an old factory for ICT companies.

The Finnish case study among others developed the method of the usability walk- through. Besides the European research project there are several case studies conducted as part of the studies of facilities management in Turku Polytechnic. The paper aims to create an overview for the usability walkthrough as a method.

2. What is Usability Walkthrough?

2.1 Usability

Beyond all definitions, office usability is about the usage phase and end-users of the office. According to ISO 9241 [1]. "A system can be said to be usable when specified users in specified circumstances with specified goals, can use it with effectiveness, efficiency and satisfaction." Effectiveness means the accuracy and completeness with which users achieve specified goals. Efficiency is described as the resources expended in relation to the accuracy and completeness with which users achieve goals. Thirdly the satisfaction is the comfort and acceptability of use. To make it simpler the effectiveness means doing right things, the efficiency means doing this right and satisfaction is the level of comfort and pleasure in doing things.

According to Nissinen (2004) the high quality working environment is not only functional but also usable. It is well known fact that the costs of office environment constitute only a small part of the total costs of a typical organization. [2]. However, the importance of working environment quality is essential for any organization due to several reasons, for instance: High quality working environment enables the office workers – the most important resource of the organization - to do their best every working day and every working hour according to today's business challenge: to do more, faster and better, with less time. For any company a high quality working environment is an important advantage when competing for the best and satisfied workers.

The methods to evaluate and measure the workplaces from the usability point of view include more than only a survey of customer satisfaction. The effort is to find out the quality and content of the user experience of the usability.

2.2 Usability walkthrough

Pluralistic usability walk through is a method, which combines elements from a usability test and usability inspection. A pluralistic usability walk-through session involves participants from three groups: the users (present or potential) of the workplace, system developers like architects, designers and constructors and usability professionals. Together the participants gather information about the usability by inspecting the workplace. All users who try to accomplish given tasks participating the usability analysis. In the end of the session the whole group discusses the findings they have made.

Cognitive walkthrough is a task oriented usability inspection method. Its focus is on ease of learning. Cognitive walkthrough is based on a theory of learning by exploration according to which users try to infer what to do next using cues that the system provides. Users do not read manual or want any formal instructions before they start to use new systems. Instead users learn by doing and exploring. The method is applied in ICT field. [3, 4, 5, 6, 7]

Riihiaho (2000) describes the usability walkthrough as the method, which guides the analysts to consider users' mental processes in detail instead of evaluating the characteristics of the actual interface. The method can be used very early in the design process to evaluate designers' preliminary design ideas and hence no running version of the systems required. On the other hand the context of the tasks and the users' characteristics must be well specified so that the analysts are able to consider the users' mental processes. [3]

In the walkthrough, the analysts comment on the sequence of actions that the users should execute to accomplish their tasks. The walk-through should always follow the right sequence of actions, that is the sequence that the designer has planned the user to follow. If problems arise in this sequence, they are recorded but the analysis's continued as if the problem did not exist. [3]

3. Why to make Usability Walkthrough?

The usability walk through can serve several purposes. It can indicate the components of usability of the workplace. It is essential to point out the factors, which are causing the high or low usability in order to improve it. Secondly it is important to get information about the factors, which are significant for usability. Thirdly the factors of usability and evaluation of them seems to be a source for interesting process of understanding and discussing about the workplace. According to Horelli (1992) the human beings are very adaptive to the environment [8]. This explains why the usability is not self evidently the elements which people demand in the workplaces. The tendency is to take the workplace as granted instead of demanding the high usability. But the increase of the awareness around usability of the workplace is a change to get into the learning process both in individual and organizational level. The process will lead to the improved usability and at its best, the process is continuous learning and evaluation cycle and an important part of organization's functions. The usability walkthrough technique is suggested as a tool to evaluate the workplaces, identify the gaps between the original design concepts and the current use, and to provide a platform for different parties to communicate.

The object of the usability walk through varies in different situation. It can focus on the use of the new workplace. It can be done in the workplace, which has been long in use or it can goal to the refurbishment of the workplace. In all these settings it is a way to investigate the relationship between the workplace and the workplace behavior and human cognitive maps. The logic in environment is a component of vital environment [8].

4. How to make Usability Walkthrough?

4.1 Usability Walkthrough in case study

This Chapter presents a case study where the usability walkthrough was used. The usability walkthrough was a challenge in the case study target, which was the Old Mill business park, which is located in the Kupittaa area of Turku close to three universities, the polytechnic, the railway station and the increasing Turku Science Park. The building itself is an old ceramic factory renovated for the use of ICT-companies. In Turku the area development strategy includes an important center for ICT-business. Consequently, the decision was taken to renovate the old factory as a modern center for ICT-companies The interior of the building has been left exposed in the renovation giving the estate its unique feeling combining modern technology with the building's historical features.

The Old Mill includes a number of additional services alongside its functional and interesting office space. The building is equipped with latest data network connections to provide the best setting possible for the ICT-companies in the estate. Tenants also have access to a number of meeting rooms as well as an auditorium for their use. Sodexho manages a restaurant in the building providing the perfect setting for business as well as private functions. Petrasol Business Centre oversees the running of the Old Mill's reception area, switchboard, as well as the building's Intranet.

The building of the Old Mill presents the imago and brand in a similar way as the name, slogans or logo. The Old Mill has its own profile and identity, which differs from the surroundings and manages to provide something unique for the companies. The expression in www-pages "From a ceramic factory to a technology center – a glance into Old Mill’s history” and **“**New technology in an old factory “ make the brand of the building exciting, unique and valuing tradition

The usability walkthrough was thought carefully and some framing was done. The interesting character of business parks encouraged concentrating in the usability walkthrough fully in shared, common and public parts of the building instead of the individual workstations. In order to clarify the objectives of the usability walk through the diagnosis of high and low usability was made by the survey for user’s of the building.

In usability walkthrough itself the end users, on various levels, evaluated those objectives, which had scored with high or low usability in the diagnosis survey. The balance of the participants is important. The team for usability walk through included

- The architect of the present structure in Old Mill
- The service provider of help desk services
- The service provider of catering services
- The facility manager
- The end user
- The usability researchers

Using the former data from the diagnosis phase the route for usability walkthrough was identified. The results were described briefly and the participants have had the chance to prepare. They got some guiding questions beforehand.

Participants were encouraged to reflect their views on the facilities and open-ended questions were asked to collate different point of views. Discussions were tape-recorded. During the walk through, the participants observed the facilities and began to discuss the causes and effects of use of spaces. Participants were encouraged to give feed back according to their own experiences on predetermined milestones:

- The entrance space
- The restaurant
- The meeting room
- The parking area

Table 1 Usability walkthrough results

VIEW	FACT	RECOMMENDATION AND FINDINGS
The entrance space	The entrance space is large and the reception/ help desk is located on the other end of it. As the desk is relatively distant from the entrance itself, it is not immediately noticeable when you enter the building. This sometimes causes confusion for visitors. *"We often need to catch visitors attention, because they don't notice us"* – reception	Make the help desk service visible. Hospitality (of reception staff) increases usability – service is an intangible attractor.
	It is assumed that visitors approach the help-desk/reception first in order to provide security (limited access to offices). Therefore there is a limited amount of signs and guidance.	People should be encouraged to **learn** to use the help desk. Host should inform the visitor about norms.
	The "lobby-area" is in low use *"People are not familiar with using such a open entrance spaces"* - architect People are not utilising this space for other purposes (multi-use), such as meeting, displaying products, events etc. *"People don't want to be seen to sit in a lobby as this means you are lazy"*'- FM	To provide information about multiuse possibilities The attractors: vending machines and touchdown desks The furniture solution - Encourage for communication and interaction (greeting and informal meeting) - Should the space be divided to provide more privacy? - Focal point to the entrance (
	The design of the space creates a "wow"-effect. *"I chose to work here because I was impressed with the design of the building"* - user	A lively and dynamic atmosphere should be created to sustain the positive and attractive impression. (From the first impression to the total experience – "wow, here is a pulse"-effect) Maintaining the 'wow' effect throughout the building -
The restaurant	*"The layout of the lunch buffet is illogical - wrong way round"* – service provider	Use the towards the clockwise Arrangements Change the location of the cashier
	The lack of information about "traffic" rules	Signs

	Limited use of two meeting rooms after the restaurant closing time	Information Room booking arrangements
	On-peak time queuing is time consuming and frustrating *"I sometimes turn back when I see the queue and come back later" - user*	Encouraging people to have their lunch on off-peak times – rewards (free coffee and dessert etc.)
The meeting room	The light and ventilation switches are illogical: Red light indicates that the ventilation is switched on – confusing message (red = danger) To control the level of light you need to press rather than turn the switch – Delay in the change of the level of light - difficult to achieve desired level. *"It is embarrassing when the lights turn off in the middle of a important customer meeting"* - user	Guidance for, and information about, efficient use.
	As a consequence after combining two smaller meeting rooms, the light and ventilation switches are not next to the new main door (having to find the switches in the dark)	Investigate new solutions (Remote control etc.)
	It is difficult to serve food and beverages in the two small meeting rooms.	Consideration of furniture solutions
	The need for larger meeting spaces has increased – more training sessions	Use of entrance space?
	ICT system and security – the same phone line for two rooms. *"We need an absolute confidentiality also during the tele-meetings"* - user	Under assessment.
The Parking area	Not enough parking space for customers. *"I sometimes have to go and re-park our customers' cars because the allowed parking time is only 2 hours – less than most of the meetings. " –* user	Help desk service can be developed

The status of usability Old Mill is quite high, but some areas of improvement have been identified. The aims for improvements include:

- Customer orientation in the car parking area. (Serviceability)
- Smarter' (multiple) use of the entrance hall - focus on different options and communication of these to the users. This encourages them to use this space more efficiently. (Usability)
- Efficient use of the restaurant lunch buffet by improving the logic of the layout.can be improved (Learnability)
- Better guidance of the ways the meeting rooms are used. The amount of information for the use of meeting rooms. (Functionality) [9]

4.2 Learning points for developing the usability walkthrough method

The usability walkthrough in the public and shared places in the business park kind of setting gave interesting results. Anyhow it caused several questions, which are worth to consider further. The user's experience of the public areas are always linked to the context of the workplace as a whole setting. The whole setting in usability walkthrough could give different results from the perspective of the user. On the other hand the group of service providers as end-users in the business park is an important group within a usability investigation.

The second issue is about the targets of usability. To the usability walkthrough in the presented case study the targets based on the results of the survey. The targets should be based on the user's experience of usability. Because the experience has its soft kind of nature it might be worth to explore if the usability attributes created by Keinonen (2000) could be a matter to apply. [10]

Keinonen (2000) has developed a model of usability for consumer products but many of the attributes he defines are also relevant with workplaces. The usability attributes are:

•Functionality (FNC)
•Logicality (LOG)
•Information presentation (PRE)
•User manual, documentation (DOC)
•Usefulness (USE)
•Ease of use (EoU)
•Affect on emotions (AFF).

The attributes described are connected to either personal preferences of the consumer, or directly to the product, or to its functionality. The first level of usability has to do with how the user perceives the concrete characteristics of the user interface of the product (LOG, PRE, DOC, and FNC. [10]

The two other attributes documentation and functionality have a lot to do with the instructions and their achievement according to the functional properties of the building. The use of lightning, regulation of room temperature, the air-conditioning – how do their function, how they can be used and how the use of them is informed. These are essential points of views of usability of workplaces.

The next level of usability evaluation contains the consumer's feeling about the quality of the interaction between her and the product (USE, EoU) [10]. In addition it might be relevant to mention two more criteria for vital environment by Horelli [8]. Besides earlier mentioned logic of the environment the vitality included the feeling that the workplace can offer an exit from daily rush, disturbances and mental requirements –it is refreshing environment. As well it offers the sense of belonging for the user – it helps a person to include oneself to the organisation, profession and goals of the work. Nevertheless it is attractive. This comes close the third level of usability, which is also the most common in use when usability is evaluated, is the interactions general effectiveness on users' emotions. This level is emphasised by consumers' personal aesthetic and value based criteria (AFF). [10]

Instead of the objects like entrance hall or meeting room it could be possible to concentrate more in the description of the qualitative aspect of the usability experience. This approach can then end up to concrete objects as indicators and visible artefacts for the usability experience.

5 Conclusions

The usability walkthrough is a relevant way to approach usability, its evaluation and development. The existence of diversity in participants characteristics and needs in relation to usability walkthrough has all the potential to impose significant challenges. Two questions still remain: whose responsibility is usability? and secondly how to attract usability experts to the organization to share usability experiences?

The method of collecting and disseminating information about usability of work places is one issue that requires further investigation. Such investigation would make it possible to build a usability profiles for workplaces. This profile can illustrate the characteristics, which make the workplace suitable for doing right things in right way and with the ease and satisfaction. The usability profiles from different workplaces could together produce interesting material to compare and classify further the elements of usability.

One other difficulty with investigating usability at workplaces is that it is impossible to create a controlled environment within which usability data can be collected. Usually usability walkthrough is carried in a workplace environment and is quite different from a designed environment on a smaller scale. This is largely because of the impracticability of designing such physical smaller scale usability environment. However there are possibilities for simulation especially in the virtual environment. This is an area that has not yet been fully explored or applied. Such usability lab is possible given the existence of supporting technologies and requires more investigation.

The usability, based on the experience of the user, is one element in the discussion about the workplaces, which support the total well being of the user. The effectiveness, efficiency and satisfaction in the workplace increase the productivity of the user – not only as a ratio between input and output but also as a quality of the work performance.

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The Impact of Hi-tech learning Environments on Pupils' Interactions

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Abstract

This study focuses on the intelligent 'classroom of the future' which characteristically make extensive use of information technology and flexible environments. The UK Government has recognised the need for radical changes to classroom environments and their facilities in order to improve learning. As an outcome of these new ideas, proposals are being developed and implemented through the UK's "Classrooms of the Future" project [1]. The behavioural analysis method described in this is used to critically examine the efficacy of the "Schools of the Future" concept.

Research suggests that students are positively disposed to new technology in the classroom environment [2]. One study has used behavioural mapping to analyze the effect of the classroom environment on the practice of teachers [3]. The purpose of this research is to determine whether these novel intelligent classrooms will affect the behaviour of children in their new learning environments. Behavioural mapping was used to observe and monitor the classroom environment and analyse usage. Two new classrooms designed by INTEGER (Intelligent and Green) in two different UK schools provided the case study environments to determine whether intelligent learning environments can enhance learning experiences.

Keywords: Learning environment, classroom environment, intelligent classrooms, behaviour, behavioural mapping.

1. Introduction

1.1 A Hi-Tech Learning Environment

The discussion about learning environments extends beyond the boundaries of a single room to a variety of settings. Learning can occur in numerous environments. Information and communication technology (ICT) are integral to this learning experience and the flexibility it affords. The measurement of successful learning can be a very complex task to accomplish. [4].

The classroom is also a complex space [2]. He states that “the classroom environment is a complex environment which poses a number on methodological problems for any researcher” [page 22]. However, observing and understanding a space can provide an indication of how well learning resources and interactions are being explored.

Figure 1 A technology-based flexible classroom

This study focuses upon new technology-based classrooms (see Figure 1), referred to as intelligent classrooms. It aims to investigate the impacts of these new environments on pupils and whether pupils’ behaviour is affected by the change of environment. Methods from environmental psychology underpin the research.

The UK government is seeking improvements in education both in terms of learning acquisition and school facilities. New learning spaces have been built or renovated. In UK about 31 new classrooms of the future were designed and are being built around the country [1]. However, some fundamental questions remain to be answered. What are schools of the future going to be like? What will be the impact of technology in early education? What changes are needed in the learning environment? Annesley et al. [5] argues that the design of a school affects the way pupils and staff interact, their motivation and self-esteem – this in turn has an effect on learning.

In this study the focus will be restricted to single classroom spaces, although it is acknowledged that other issues such as grounds and circulation areas may also play a significant role. The study explores key factors that seem to have some influence in this process: the flexibility of the space, the mobility of the teacher and the use of new-technology. New technology enables flexibility and mobility, both of which are analysed in the study. In addition, human interactions in the classroom are analysed in order to find out if technology-based classrooms enhance learning.

1.2 An intelligent classroom

Study by Underwood [2] already indicates that students are willing to accept information and communication technologies (ICT) in the classroom environment. Dudek [6] argues that schools and their educational needs are changing and that information and communications technologies are expected to transform the classroom. School facilities, including the classroom, are already facing changes to meet the needs of the ‘communications age’. Figure 2 shows the use of information and communication technology in one classroom took as case study.

Figure 2 A n intelligent classroom environment

There is a belief that "in the classroom of the future the learning environment will look and feel different" [1, page 79]. The intelligent classroom, in this research, considers two aspects: technological (or technology-based) and sustainable. The technological aspect looks at the building as a product that: **a.)** makes extensive use of information and communication technologies such as wireless computing, video-conferencing, interactive whiteboards, that enable individual and group work as well as electronic links to other schools and facilities; **b.)** has flexibility as a central theme to enable a variety of different learning environments; **c.)** provides movable, attractive and adjustable furniture suitable for a wide range of ages and sizes facilitating use of the new learning technology.

The other aspect of the intelligent classroom concept is linked to sustainability or green buildings. According to Edwards [7] "sustainability is increasingly seen as the only legitimate architectural design issue for the 21st century" [page 83]. He also tries to establish a link among productivity, technology and sustainability and states that these three factors "are quickly being recognized as an important package of interactions, especially in working environments" [page 83]. Environmental (green) issues in the workplace are also discussed by McGregor and Then [8]. They argue that both providers and occupiers of buildings are realizing, increasingly, "that workspaces need to be provided in an environmentally responsible way" [page 121]. This research investigates these sustainable workplace ideas by looking at school environments which were conceived as intelligent *and* green buildings.

2. Multi-Method Approach

A multi-method approach was employed in the research in order to avoid bias (as advocated by Zeisel [9]), who argues that using several methods to attack one problem achieves higher-quality research, suggesting that "the appropriate mix of methods will be the one that enables you to achieve your ends with the greatest control over side effects" [page 229].

This research is based on comparative case studies of two new classrooms and two traditional classrooms at different schools. Two main methods were used: behavioural mapping (through class observation) and questionnaires. In addition, two other tools were used to elicit information: interviews were carried out in the beginning of the field work and a feedback box was set up in the studied environment.

2.1 Behavioural mapping

Rivlin and Rothenberg [10] define behavioural mapping as a naturalistic time-sample technique for describing patterns of activities and the use of physical space. Zeisel [9] describes similar technique named as behavioural plan annotation in which information about the relation between the environment and behaviour is recorded.

Horne [3] explored the behavioural mapping technique in her observations in classrooms. She argues behavioural mapping is an efficient tool to get a clear understanding of the classroom environment. It is generally believed that behaviour is affected by the environment and the environment in turn is changed or adapted to accommodate different behaviour.

Behavioural mapping was chosen since it allows several graphic maps to be produced during an observation session. Every 5 minutes a map of the physical space or physical settings (as defined by Proshansky [11]) was produced and information was registered. Ittleson *et al* [12] suggested time intervals of 15 minutes, but variation is possible. The observations were mapped on floor plans of the classroom, annotating layout, teacher's movement, interactions among users and with the environment, record of activities and their duration.

2.2 The Constructs and Terminologies

Various constructs were developed by Horne [3] to help class observation techniques. Some of them are described here. *Lesson profile, flexibility of the classroom, mobility of the teacher,* and *density* are constructs being used in this research. Another factor, *interaction*, was added and is being investigated in order to check the relation of the new learning environment with possible interactions among users. This factor has also been used before by Horne, but from the teacher's perspective. In this research the focus is on pupils.

Some constructs and terminologies described in this session were used in the research and originate from Horne [13] with some adaptations: **a) Lesson profile** is a column that identifies the clusters of activities (introduction, teacher teaching, pupils on task, transition, and conclusion; identified to describe the different activities that occur in the classroom. **b) Flexibility factor** of the classroom "is the total area in each room that allows change to be made by the teacher with varying degrees of effort" [page 143]. **c) Mobility factor** of the teacher is the total area covered by the teacher during the lesson in relation to the total area of the room. **d) Density** is the amount of space per pupil in a classroom measured in square meters per pupil**; e) Interactions** mean relationship between users and the new learning environment. These interactions were classified in 5 categories in order to be quantified and to investigate if there is any relationship with the other factors. As the focus of this study is the pupils, the possible interactions were identified: 1. pupil-to-pupil, 2. pupil-to-teacher, 3. pupil-to-equipment, 4. group interaction, 5. no interaction; **f) New-Technology** is introduced to refer to leading information and communication technology (ICT) which includes interactive whiteboards, laptops, web-tablets, video-conference, scanners, printers, and digital cameras. This equipment is available for pupils and teachers alike and can be used to support both group and individual working.

2.3 Physical Settings

Two new classrooms designed by INTEGER-Intelligent and Green as part of UK Government project named "The Classroom of the Future" provided the case studies for this research. The goal of this government project is to enhance learning acquisition through innovation in the school environment. Several such classrooms have been designed and built around the country. Telford and Wrekin Local Education Authority (LEA) has these two new classrooms in two different schools: The Lord Silkin (secondary school) and Wrockwardine Wood Church of England Junior (primary school). Two locations were used for class observation in this research. In addition, pupils were observed in both traditional and new classrooms to provide a control.

Table 1: Summary of the school classes studied.

Case Study	***School***	***No. of pupils***			***Age group***	***Stage****	***Year***
		Male	*female*	*Total*			
01	Wrockwardine Wood Church of England Junior School	15	14	29	7 - 9	Key Stage 2	Year 3 and Year 4
02	The Lord Silkin School	20	17	37	15 - 16	Key Stage 4	Year 11

* Related to DfES (Department of Education and Skills) [14]

Location 1 Wrockwardine Wood Church of England Junior School is a primary school attended by pupils at Key Stage 2 with 10 classes from Year 3 to 6. The classroom of the future built in this school was in use by all school pupils. One class of 29 pupils who were 7-9 years of age was chosen for class observations (Table 1). This choice was based on the convenience of matching the schedule of the secondary school observations. Students were observed in the new learning environment and in the traditional classroom (see Figures 3). The same group of pupils, the same teacher and the same subject were observed in both environments.

Location 2 The Lord Silkin School is a secondary school built in Telford and Wrekin Local Education Authority. This school is now applying to become a specialist school in business. The classroom of the future built in this school has been used by these business students. It is the same original design with slight differences in terms of cladding, decoration and different external deck. One single class of 37 pupils, 15-16 years of age (Table 1) was chosen as the second case study. Students were observed in this new classroom and in the traditional learning environment (Figure 4). Again, the same group of pupils, the same teacher and the same subject in this school being observed in two different environments.

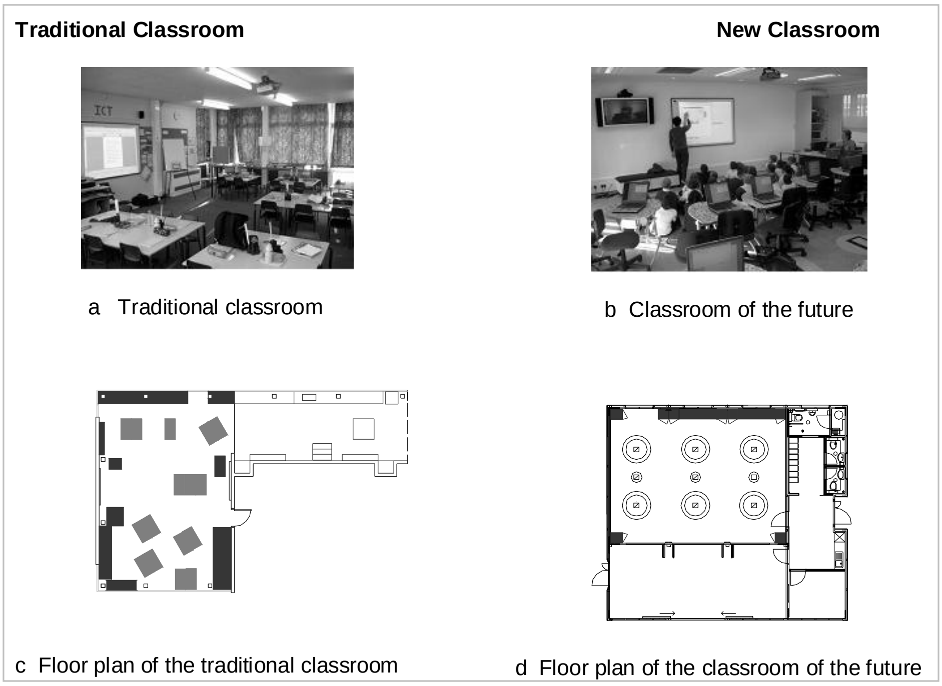

Figure 3 The two physical settings at Wrockwardine School

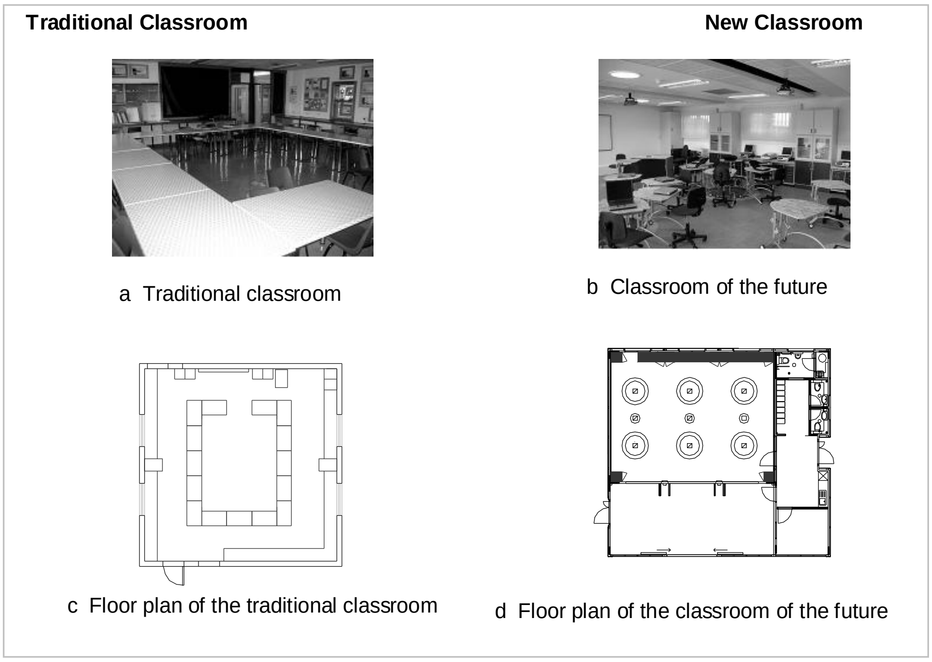

Figure 4 The two physical settings at Lord Silkin School

2.4 Methodology

Interviews were carried out a few months after the launching of the classrooms which occurred last September 2003. Data gathering was structured based on the case studies described above.

A total of 64 class observations were planned. Pupils and teachers were observed in the new and in the traditional classroom for comparison purposes. In this way the sample has 4 physical settings (4 classrooms: 2 “classrooms of the future” and 2 ‘traditional’ ones) in two different schools. Each lesson observed would generate 10 behavioural maps in a total of 640 maps, considering that it could be reduced due to school dynamics.

Questionnaires were also used in the study. Considering a classroom a space where behaviour is an important observable factor, the behavioural mapping technique allows information to be gathered about this learning environment. However, observation in turn relies on interpretation of what was observed. Swetnam [15] argues that case studies are often classified as qualitative by definition. “Observation is essentially observer-oriented” [16,, page 9] having thus a degree of subjectivity. It means observation has limitations and information can be missed by the observer. Zeisel [9] states that it is crucial that the observer be aware of what he is looking for and what needs to be observed.

With research focus on teachers, Horne [3] used interviews to validate the data originating from observation. In this research, another technique was used since the focus is on the pupils. The use of questionnaire at the end of the observation process allowed the validation of the data collected from observations. The focus of the questionnaires was the users’ views of their experiences in the new environment. All pupils in the classes were given a questionnaire. The sample size for questionnaire in a qualitative study, as suggested by Allison et al.[16], needs to be only large enough to ensure a wide variety of answers. It was agreed with teachers that questionnaire would be a class activity, which produced a large number of responses.

Other tools were used to get feedback from users of the classroom of the future in both schools. A feedback box was set in each ‘Classroom of the Future’ and open-style forms were made available for users to give their feedback about the new environment. These boxes were collected at the end of the academic year. Interviews were also undertaken. Some teachers and pupils were interviewed at the pilot study stage to get impressions and expectations about the space.

3. Results and Discussion

3.1 Findings

Only initial findings were available at the time of writing. However the study has already shown some preliminary results that seem to support the hypothesis that ‘intelligent learning environments can enhance learning experiences’.

Figure 5 illustrates how some of these factors have been observed and recorded. Interactions were mapped graphically. Each five-minute map has tracked the teacher's movement and by overlapping them it is possible to calculate teacher's mobility. Furniture movements were measured to allow for calculation of the flexibility of the classroom.

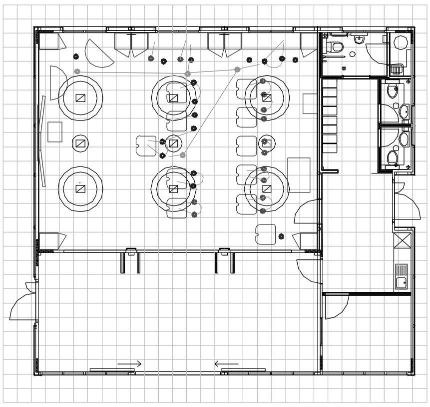

Figure 5 An example of a 5-minute map showing interactions in various categories, the layout for that lesson and teacher's tracking

Initial analysis of the behavioural maps has shown that interactions occurred more frequently in the classroom of the future as shown in Figure 6. This figure represents two observation sessions of the same group of pupils (secondary school) involving the same teacher and the same lesson subject in the two different learning environments: the traditional classroom and the classroom of the future. Four major factors that relate to interactions and their relationship have been identified: (1) interactions, (2) flexibility, (3) mobility, (4) technology.

The flexibility of the space in the classroom of the future is much higher (93%) than the traditional classroom (85%), encouraging more mobility from the teacher. Although the traditional classroom has a sizeable flexibility factor it has not been made use of.

Also the new technology in the classroom of the future has permitted the teacher to move around the classroom much more in the new environment (66% mobility). In the traditional classroom, where technology is limited, the teacher tends to be less mobile (15% mobility). Both use of technology and mobility seems to generate more interactions to occur in the new environment.

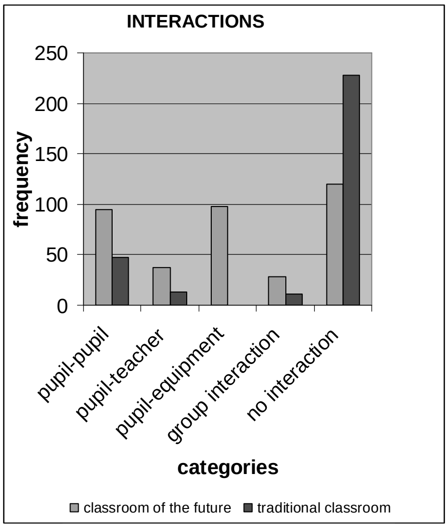

Figure 6: Interactions observed during 2 sessions in the secondary school

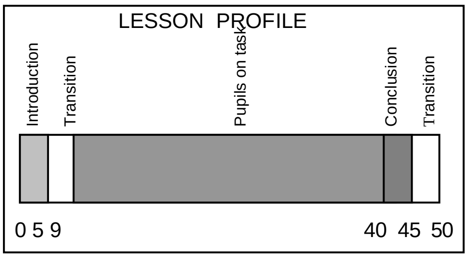

Figure 7: Lesson profile in traditional classroom at Lord Silkin School

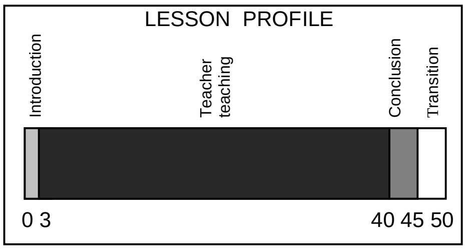

Figure 8: Lesson profile in classroom of the future at Lord Silkin School

Another important finding from the maps is the lesson profiles. They indicate that, in the classroom of the future, there is a tendency to have a more child-centred lesson as can be seen in the lesson profile in Figure 7. Pupils spend more time on tasks. In the traditional classroom the lesson profile (Figure 8) shows that the teacher spends most of the time teaching in the context of a teacher-centred lesson.

3.2 Relationships

Findings from the observations indicate that relationships exist between factors being investigated in this research. These relationships suggest that more interaction is stimulated by the new technology-based classroom.

Mobility and Flexibility The observations showed that flexibility seems to be directly linked to the mobility of the teacher. By comparing teacher movement in the traditional and new classroom it is possible to identify greater support for mobility in the new classroom. Furniture layout is routinely rearranged and equipment is relocated.

Mobility and Technology The new classroom has more equipment (laptops, web tablets, printers, interactive whiteboard, video-conference equipment) available for pupils to use (each student can have one piece of equipment for his own if necessary)

and evidence suggested that it was being used. The teacher was significantly more mobile in the new environment. Pupils only use the technology if the teacher invited them to do so. Only the teacher was tracked and mapped in terms of movement, but through observation it was possible to identify that there was also more movement of pupils in the new classroom due to new technology available.

Mobility and Interactions It was found that the more mobility the teacher had, the more interaction occurred amongst pupils. This was most obvious in the secondary school. In the traditional classroom the teacher spent most of the time teaching in front of the classroom while in the new one the teacher moved around interacting with individuals or groups. This was also apparent in the primary school. Observations indicated that the layout also influences the likelihood of interaction.

Interactions and Technology The technology available in the classroom of the future allows more teacher-pupils and pupil-pupil interactions. There was a belief at the beginning of this research that interaction may drop off when students used their own individual equipment. However, observations indicated that interactions seem to increase. The teacher was inclined to move around to teach and help pupils with the equipment. Pupils also interact more with each other and often worked in groups to help each other with the equipment.

Interactions and Flexibility By comparing the layout in the traditional and new classrooms (mainly in the secondary school) it is possible to state that the flexibility allowed by the new classroom has encouraged meaningful interactions. The traditional classroom in the secondary school has a horse-shoe shape layout that encourages the teacher to stay in the front of the room and the students to sit quietly around the horse-shoe shape desks arrangement. It produces few interactions. Most of the interactions that occur are teacher-group or one-to-one. In the new classroom a more flexible space has allowed more interactions as the teacher has more mobility. Pupils also have greater opportunity to interact with each other and in groups.

Flexibility and Technology A relationship was observed between 'flexibility' and 'technology' found with wireless technology together with movable furniture creating more flexibility in the observed classroom.

All these relationships can be summarized in a diagram as illustrated in Figure 9. It indicates that the use of new technology, flexibility and mobility all allow more interactions to occur.

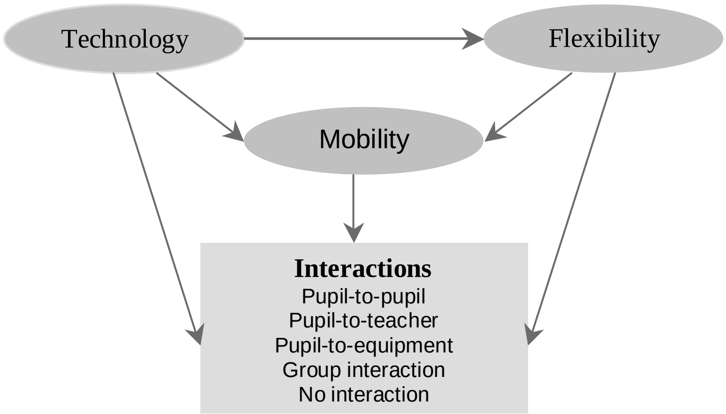

Figure 9: Relationship among key factors

4. Conclusions

This research sought to investigate the impact of new classroom environments on pupils and whether pupils' behaviour is affected by the change of environment. The research also shows a new way of examining the classroom environment with the focus on pupils.

The study has shown that developments in classroom design needs to consider technology as a key factor. Pupils are comfortable and become familiar with the use of new equipments and technology. Teachers are being trained and encouraged in the use of technology in their classes. The use of new technology-based environments seems to have positive effect on the learning process, in the delivery, interpretation and reuse of information. Pupils' behaviour was observed to improve in these environments. The pupils seemed stimulated by the new technology and also by the appeal of the classroom spaces. Teachers also felt pupils were stimulated by these new learning environments. Interactions seemed to increase as discussed previously due to factors such as flexibility, mobility and technology. This confirms flexibility as another important issue in building design and workspace design.

Further studies in this research will investigate productive interactions as suggested by Littleton [17]. It is expected that it will allow some understanding of whether learning acquisition has any relationship with interaction levels. The assumption that high levels of interaction are necessarily 'good' needs further analysis.

It seems to be clear that an intelligent classroom will demand more investment, maintenance and management. It becomes a more complex environment and needs to be well planned and designed in order to attend to the demands of teachers, pupils and the community at large.

Intelligent classrooms present a new approach for learning environments. These environments seem to be a new way of stimulating pupils’ curiosity, initiative and autonomous learning. The flexibility existent in these classrooms facilitates interaction and it seems to help group and independent learning. The accessibility to and use of information, made easier through technology, introduces new practices in the classroom. A new way of learning is brought about by the intelligent classroom. In order to discriminate between effective and ineffective innovations in such environments, analytical tools such as that described in this paper should be adopted.

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Architectural design as an enabling resource for end users in K-12 schools

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Abstract

This paper discusses architectural design as an enabling resource for end users in K-12 schools. It also presents work in progress and preliminary results from a doctoral program project that investigates the relationship between architectural design and educational outcomes. The main focus lies on a case study concerning a K-12 school built in the late 1960s and situated in a socioeconomically deprived and mainly immigrant catchment area in Sweden. There is surprisingly little research done in this field so far. The author argues that there is potentially valuable knowledge to be gained through this research for all actors involved in school design, development and maintenance. The proposed research would focus on client and end user perspective through continuous evaluation of the fit between organizational goals and results, end user experience and architectural design. Prior to the doctoral program the author had been working with development of ICT environments and applied ICT projects for higher education, research and development since graduation in1997.

Keywords: Architecture, Design, Evaluation, School buildings, Educational outcomes

1. Introduction

1.1. Industrial relevance

The industrial relevance of having access to scientific research about the relationship between architectural design and learning environment is imagined as follows:

- The development and application of ICT is one of the major drivers for change in societies all over the world. Good educational systems becomes a strategic asset as we move into a global knowledge society with a knowledge-based economy demanding life-long learning [1].
- There is a rising demand for international benchmarking and national school quality assessments. This demand constitutes a new incentive for clients, such as local authorities, to try to connect the cost of facilities and activities to educational outcomes [2]. Facilities may get a new role in adding value (or the opposite) to learning activities for the client responsible for educational facilities. At the same time globalization and increased interdependence, such

as within the EU, create an international marketplace for the construction industry. The industrial contender who has the best understanding of the evolving end user needs and expectations down to the local level will then gain competitive edge.

– Educational reform in Sweden increasingly put the individual learner in focus. Learning is perceived as taking place in a socio-cultural context where interaction and communication is essential [3]. At the same time educational activities are to be adjusted to meet individual needs and thus calls for various modes of tuition and self-studies. The bulk of existing schools however was not designed to meet this need and does not always offer the necessary flexibility.
– As ICT becomes more and more integrated into building systems on all levels it is safe to say that professional architects and builders will have to learn more about how end users interact with and benefit from ICT application in real-life contexts.

1.2. Research horizon

1.2.1. Molecular level research

Many scientific research studies have been done on a molecular level about how factors in the physical school environment affect prerequisites for learning and health. Standards and recommendations regarding environmental factors such as noise levels, air-quality, temperature and lighting have emerged. Still there seem to be difficulties in the application of the very same standards and best practice. For example, in 2001 ventilation was still the single most common object for complaints in Swedish educational facilities, as it had been for 10 years, according to a study in by the Swedish Work Environment Authority [4].

1.2.2. Molar level research

Hitherto there has been very little architectural research about educational facilities at all in Sweden [5] [6]. The most well-known example is probably a study by Skantze from 1990 about how children view their school work environment [7]. Another more recent example is a PhD thesis in architecture by Patrik Bjurström on modern Swedish school buildings, their meaning and the ideas behind them studied through a series of case studies. Unfortunately there is even less scientific research done about how architectural design relates to educational outcomes in formal learning environments.

In a study initiated by The Swedish Association of Local Authorities the question was: “Does better facilities give better educational quality?” [8]. An initial survey with questionnaires was distributed to pupils, teachers and principals in about 100 compulsory schools in Sweden. According to the study nearly 25% of the schools had good facilities, but in general the facilities were unsatisfactory. For the statistical analysis they created an educational quality index to which various factors were tied and related to educational outcome in terms of results. The authors point out that it was difficult to find appropriate measurements for educational outcomes in Sweden and that they had to settle with grades in year 9. The four factors that had the greatest importance to explain variations in the index was, in falling order: 1) management and organisation, 2) teacher competence, 3) the physical school environment and 4) textbooks and teaching aids. Even if the physical environment does have an effect on variations in this index, the conclusion in the study is that it is of little use spending more resources on facilities in order to improve educational outcomes. Despite being a promising initiative the study is problematic for several reasons. One is that the resulting report included a quality development tool targeted at politicians and employees in local authorities responsible for education. The text in the report might persuade readers to actually believe that by following the model to allocate resources you will improve school quality (and thus educational outcomes) accordingly with an accuracy down to two decimals. This seems particularly problematic since the study only used questionnaires to establish casual relationships about a complex real-life situation. Facilities are treated in very general terms and the study does not, and cannot, describe differences between different schools in any detail. This paper argues that research about the relationship between architectural design and educational outcomes need a combination of methods, both quantitative and qualitative, and perspectives to be of practical use for school development.

In the USA an interesting approach to studying the relationship between architectural design and educational outcomes have developed over the last couple of decades. It is a design patterns concept that stems back to the investigations by Christopher Alexander and his colleagues in the 1960s and 70s [9] [10] [11]. Basically the idea is that to any well-defined design problem it is possible to create a design pattern that captures the essence of the solution to the problem. It should then be described in such a way, through text and diagrams, that the pattern will be generic and practically useful. Lackney and Moore (architectural researcher and behavioural scientist respectively) have developed sets of design patterns and design guidelines for educational facilities that they suggest promote learning [12]. These patterns are primarily based on meta-analysis of scientific studies and best practice literature within behavioural science, pedagogy and architecture as well as on their own empirical studies. The patterns that Lackney and Moore considered the most strongly supported were used as a starting point for items in the initial survey among principals as part of the doctoral program project that this paper describes.

Evaluation research of school buildings has been around for some time, but is still not very common. As early as in the late 1960s the Building Performance Research Unit (BPUR) at the University of Strathclyde, Scotland carried out post occupation evaluations of some 50 comprehensive schools in Scotland. Later the POE concept was developed, primarily in the USA, into handbooks through the work of researchers like Preiser, Rabinowitz and White [13]. Different versions of POEs are now in use for evaluation of buildings all over the USA. According to Lackney there were still very few POEs conducted on educational facilities in 2001. A promising way forward for POEs in educational settings seems to be through institutionalisation, as proposed by Zimring in 1988 [14]. POEs become a standard operating procedure for local authorities, such as the New York City School Construction Authority

[15]. In his paper Lackney also mentions the State of California and their Department of General Services (DGS) as an example where state policy has potential of institutionalise the POE in educational design practise. In 2002 the California DGS have named their own POE version FPE, or Facilities Performance Evaluation (see http://www.poe.dgs.ca.gov/default.htm).

1.3. Approach and methods

1.3.1. Applied research approach

This case study is part of a doctoral program project that also has a practical, or applied, purpose. It might therefore be considered applied research. This purpose is: to contribute to the knowledge of local authorities and schools in general, and one specific municipality and school in particular, with recommendations for application in development of formal learning environments; and to contribute to the knowledge of practitioners / architects with recommendations for design of formal learning environments. It is common practise for architects to take a holistic stance to the design problem at hand and try to merge technical, economical, functional and other aspects into an aesthetic whole. The author also takes a holistic stance in approaching the case in order to investigate the research question from several angles.

1.3.2. The case study research strategy

Given the applied research approach and the opportunity to investigate the research question in a real-life context a case study research approach seem feasible. Robert Yin is an authority within case study research and his handbook is widely used [16]. In his view the method is what characterize a case study. His approach includes both qualitative and quantitative methods but with an emphasis on quantitative analysis. The focus is on the instrumental case study and deductive theory testing. In this particular case the objective is to try to learn as much as possible about, and from, the case in itself, not necessarily to strive for universal generalizations. That makes Robert Stakes approach to case study research relevant as a complement to Yin's. In Stakes view the case itself is what characterize a case study [17]. Compared with Yin, Stake is an advocate for a more qualitative focus, but does not exclude quantitative methods. His model of thought is based on hermeneutics, on abduction and induction through grounded theory, striving to create a whole picture. In terms of generalizations Stake uses the term "Petite generalizations" to mark the kind of generalizations that you can do within the specific case. Outside of the case it is possible to make Naturalistic generalizations according to Stake. Every practitioner builds a repertoire of cases that can be referred to in problem solving. This notion is also supported by Donald Schön in his work on reflection-in-action [18]. Stake claim that the repertoire of cases can consist of conclusions made from personal real-life experience, but also of stories about cases that are so well told that it feels as if you had experienced it yourself. Stake prefers the story as the format for reporting on the case study.

This case study primarily makes use of Stakes approach, as it fits the background, purpose and context of the case with regards to the research question. Stake works with issue questions for negotiating the study. Etic issues that the researcher brings in from the outside, and emic issues that emerge from the case and the people inside the case. As the work develops these issues are restated and transformed into tentative assertions that take form of the Petite generalization. These may in turn develop into Naturalistic generalizations made by the readers of the report themselves. Stake use the term progressive focusing to describe how the researcher moves through the issues during the study. At this time the issues relevant for the paper will be divided in two categories: initial issues and issues under development.

1.3.3. Data collection

- 10 interviews, including one group interview, have been recorded in digital audio format and transcribed for coding.
- Each interviewee filled out a questionnaire identical to that of an initial survey among the K-12 principals in the municipality. Each questionnaire was completed in the presence of the researcher who could answer questions about the items, definitions etc.
- Data from the end users were also gathered on three occasions through the walk-through evaluation method called “Gåtur”, described by Ambrose and DeLaval [19] [20]. In this particular case the Gåtur consisted of eight stopping points on the premises that the researcher found considered as key locations for understanding the case. Two was done with faculty and staff and one with pupils. The material from protocols, notes and recordings will be coded for an aggregated data analysis.
- Observation notes were taken both from classroom sessions and walking around the school.
- Protocols have been made with notes from various conversations and improvised interviews.
- Some 500 digital images were taken of the facilities. A photo album with comments from the construction period in the late 1960s is borrowed from the principal.
- A large number of documents have been collected from both the school and the local authorities. These include for example: drawings, diagrams, statistics, rules and regulations, instructions for teachers, internal reports and protocols.

2. An empiric example

2.1. Main context

2.1.1. Background for the study

The study referred to in this paper has both an intrinsic and an instrumental character. It is intrinsic in that the main object of study, the K-12 school, was given beforehand due to an agreement between the university and the local authorities to make a joint effort in a local, real-life context. This particular school was chosen for several reasons. One reason was the fact that it has a tough setting, situated in a socio-economically deprived and mainly immigrant catchment area. The school was also considered by the local authorities to be worn down after 35 years. The Swedish National Agency for Education specifically called for improvement in terms of educational outcomes in this municipality. The study is therefore instrumental in the respect that the issue of the importance of the physical environment as a prerequisite for the learning activities can be studied.

2.1.2. The case study school

The main building was built in the late sixties and complemented in the 70s with a separate pavilion to house additional classrooms. The pavilion is still there, even if it had to be demolished and rebuilt due to health hazards in the 1980s. Today there are about 350 pupils from kindergarten to year 5 and about 80 adults in faculty and staff. The main building layout has an E-shaped plan where classrooms are located in the wings. Each classroom is connected to a small lobby/group space/corridor section with a door to the outside. In between each wing is a small yard mainly covered with asphalt. But there are also small patches of grass with a couple of young trees, a few large sandpits and a climbing structure. The predominant features of the exterior are the low one-storey profile and long rows of windows on all sides. In recent years the kitchen has been renovated and expanded and a ventilation system has been installed that slightly breaks silhouette of the roof.

2.1.3. Surroundings

The site is flat and has modernist residential building complexes from the late 1960s on three sides. The location towards the periphery of the small community put the school only a couple of hundred meters to the forest. Some teachers pointed out in the interviews that the relative close proximity was a major, if not the major, asset of the schools physical environment. The teachers enjoyed taking their pupils to the forest on excursions. The local community where the school is located has a small modernist centre with a few shops and basic service.

2.2. Initial issues in the case study

Initially there were a number of larger and smaller etic issues in the study and the following still seem relevant for this paper:

- How does architectural design affect the prerequisites for learning in this K-12 school?
- How can architectural design be an enabling resource for learning?
- How do the end users react to malfunctions in the physical environment?
- How does the design matter according to the principals in the municipality?
- How does design matter according to teachers and staff in the case study?

- Which of the supposedly supportive American design patterns can be identified in this case?
- Are these design patterns a relevant concept for developing architectural design that work as an enabling resource for learning in K-12 schools?
- What expectations do the staff and faculty have about the importance of ICT for their future learning activities and physical learning environment?
- Which design factors seem the most important to the end users?
- Which are the specific end user needs and expectations in this K-12 school?

3. Preliminary results

The case study format lends itself rather badly to account for results before the final report exists. Aggregation of data is underway through coding of transcribed interviews that, at the time of writing, only can be analysed through direct interpretation. Also the data has not yet been studied enough for deciding the necessary data source triangulation and method triangulation. In the following sections the "preliminary results" comprise of issues under development.

3.1. Issues under development

- So far there is no evidence in the data that the facilities are part of the school quality assessment. A tentative assertion from the interviews is that a strong incentive for design evaluation of municipal K-12 schools has been missing until now.
- Analysis of interviews done in connection with the initial survey among principals suggest that potential health hazards are their most powerful argument for change in the physical environment. How would design evaluations in relation to added value for the learning environment affect the argumentation?
- Crowding seems to be a substantial problem to some teachers. In interviews and conversations members of staff and faculty express the notion that disturbing noise levels among the pupils are a direct result from crowding, but also a result of the catchment area characteristics with a lot of anxiety among the children. The integration of pre-school activities and classes that is now taking place at the school is also related to this issue.
- At the moment of writing it can be noted that the protocols contain a total of 209 negative observations and 119 positive observations in total. There are also 127 suggestions for change. The pupils' observations will have to be complemented by analysis of the sound recording since they did not always use their protocols.
- Why does the individual fail to notice things that actually work well? It is not until something actually malfunctions that some end users seem to notice the physical environment.

- The end user expectations seem to be somewhat restrained by a general notion of cut back economic resources for municipal schools over the years and the specific notion that the school is in low esteem due to its history and current situation with a socio-economically deprived mainly immigrant catchment area. This observation gets some support in a book from 1999 about planning school buildings in Sweden. There the architect Lena Dranger Isfält claim that within Swedish school traditions there is an attitude towards facilities and furniture that it is something that is provided for you, and that it is something you yourself cannot do anything about [21].
- Even if some teachers express that they have given up hope for improvements of their physical work environment, they still have the feeling that it should be in another way. Many teachers have experience form other situations and schools that serve as references when thinking about the current situation.
- Data from interviews and walk-trough evaluations suggests that some end users finally give up. They stop taking initiatives to do the little things they actually can do by themselves to improve the situation. As committed professionals they have been adapting and trying to overcome the limitations of the physical environment. They say “Well, I am the kind of person who always try to make the best of the situation, but…” In essence they claim that it takes to much resources (time and stamina) away from their teaching and learning activities. It is no use making small efforts since the school needs substantial improvement and they feel that they really cannot do anything about that.
- Future educational facilities are likely to include a mix of real, augmented and virtual environments for learning activities. How can ICT be used to expand the use of educational facilities?
- There seem to be conflicting views on the approach towards the children in carrying out the schoolwork. Some people would like to give the children more freedom to choose for themselves and more responsibility while others stress the importance of keeping a “short leach” in order to create a safe and sound environment that minimize the level of anxiety and unrest among the children who are considered (by all interviewees) as being more lively and out-acting than average. How does the attitude towards the children regarding their need for regularity and rules affect the way the facilities are being used?
- Interviews indicate that, just like medicine, teachers must act in the right conditions to have the desired effect. They must have a chance to set the scene and interact with the children in a way they consider appropriate for the situation and task at hand. If the current faculty cannot work efficiently due to a cramped space situation, would adding yet more qualified teachers have the desired effect?
- ICT equals a PC and an Internet connection according to the interviews and the conversations. The notion of for example interactive thin displays on furniture and/or building parts in their learning environment is a very distant thought for most interviewees.
- Why is it that even though everybody seems to agree on that the need for substantial renovation and redesign has been around for a long time, nothing has happened?

- The canteen, as well as other common and worn down spaces, seem to provoke negative emotions and frustration among the interviewees. The colours are ugly, the lighting is bad, the acoustics are bad, the general layout is not functioning well etc. The same description would apply to several other places, such as their own classrooms, but it does not seem to provoke the same emotional response. Could it be related to a feeling of responsibility – or guilt? That in “your own” room you are somehow more to blame for every shortcoming in the environment, while in the shared spaces no one seems to take the full responsibility?
- So far no data in this case study contradicts the notion that the local authorities do not have access to reliable and updated information about the building performance in relation to the needs and expectations of the end users. How do those responsible to make informed decisions with respect to quality go about to prioritize in the educational facility budget without seemingly necessary information? Some people in the study claimed that it was due to the fact that the school is in a mainly immigrant catchment area, but the school do receive extra resources in terms of teachers for the same reason.

4. Discussion

In economic terms municipal schools does not have the purpose to generate money. The goals are described in the national curriculum that changes over time. The activities aim at letting young people obtain valuable knowledge and know-how, but also to give them the opportunity to develop as individuals in a social setting that prepares them for adult life. Therefore it is safe to say that the output of school activities is complex and difficult to measure. In terms of results there are some variables that can be measured, such as; academic achievement through test results, grades and the amount of pupils that obtain results that meet minimum requirements.

A protracted design phase, or a continuous design cycle, means smaller interventions and more often. There might be a market for flexible design solutions with multiple utility spaces that can expand and contract smoothly. In some cases it might be a matter of organization and co-habitation of clients/end users. In other cases the solution might involve ICT for tele-presence and virtual reality (or virtual space rather)

Most POEs (and other facilities evaluations in Sweden) still seem to focus on “hard” technical issues of building performance. The focus on the technical issues brings forward easily measurable variables. This might obscure more complex issues and variables concerning the activities and interaction that also have substantial impact as a prerequisite for learning in formal learning environments. I suggest the added value that Ang, Wyatt and Hermans discuss within the domain of use and facility management should also apply in the municipal context, even if the “business process” are somewhat different [22].

Preliminary results indicate that there are a lot to be learned from studying the problem out in the field and collecting data first-hand. Design solutions and interventions benefit from knowledge about the actual end user. Every country and possibly every municipality down to the single school will have slightly different prerequisites concerning all variables that are thought to affect educational outcomes. From a pragmatic viewpoint it would make good sense to address the issue of design and evaluation on the lowest possible level and to assemble all relevant data in databases for cross-case analysis and reference.

Minor changes in maintenance do not seem to be a big issue or matter that much in the whole. However, many small changes made in a patchwork manner will affect the whole. Each little alteration might be perfectly rational in the short term. The long-term consequences will risk getting out of our control unless there is continuous and updated documentation and evaluation available for analysis. On one hand there are serious ethical problems building schools as scientific experiments. On the other hand, building and running schools without employing scientific knowledge or evaluation is also a kind of experiment with the end users life in the workplace. It is just not stated as such. Continuous design might be one strategy to deal with changing prerequisites and to achieve better fit between design and end users needs and expectations. Perhaps not all economic resources need to be spent at once. Some resources could be put in a redesign fund for each school. Every space in a novel building might not have to be "finished" or furnished to the highest standard at once, but could retain a slightly more rough or robust character.

There might be other ways of improving the fit between design and learning. The initial analysis of interviews and conversations also suggests that clients and end users would benefit from having access to an "expert end user" or, perhaps better formulated, an "environmental coach" who would assist and coach the clients and end users in the possibilities and limitations of the physical environment of their school. Another approach would, in line with the notion of continuous design, be to use a "learning solutions designer" who could access a municipal best practise reference database and provide each school with individual solutions while keeping track on previous alterations.

Finally it is striking how teachers and staff were pleased with someone asking them for their experience, what they think about their physical work environment and what they would change if they had the opportunity. In several cases the interviewees stated that this research was important and that it was about time someone looked into the matter. The interviews indicate that talking about the physical environment also provided a good starting point for discussing a wide range of other issues related to organization, identity, values and culture.

5. Conclusions

As mentioned in the results section it is rather a awkward business trying to extract traditional results, or conclusions, from a case study of this kind before a final report exists. Still, it is important and valuable to share reflections and assertions above in relevant forums, even if the format is not ideal. The conclusions at this stage would be that there seem to be a need for research about architectural design of formal learning environments in relation to educational outcomes. As for the direction of future research the issue of incentives for evaluation seems most important, but that it is necessary to look for the criteria in the local context. The question of accounting for added value, or how well the facilities support learning processes, in the eye of clients and end users may well be a key to future success for both architects and the construction industry.

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Place Attachment and Sense of Belonging in the Offices

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Abstract

Organizations are often forced to modify their physical environment and relocate employees in response to new business strategies. However, the impact of these changes on employees is rarely considered. Many organisations are acutely aware of the costs associated with high staff turnover, staff alienation and recruitment. Recent innovations in workplace design such as hot-desking have further undermined our sense of belonging. This research considers the attachment employees have for their established work place. It is argued that this attachment may influence people's response to the new environment and the move process. Issues of place attachment, personal expectations and perceptions can affect a person's response to a changed environment, which may be at odds with a strong organisational imperative for a move. To date, however, our understanding of how these factors relate to each other is limited. This study seeks to expose the gaps in our understanding of 'attachment' as a phenomenon. It describes the methodology that will be used for a subsequent case study, which attempts to quantify and qualify the phenomenon of place attachment in the workplace. In particular it suggests how design elements can be introduced that nurture a sense of belonging in an organisation.

Keywords: Change Management; Place Attachment; Relocation; Sense of Belonging; Workplace Design

1. The Research on Workplace Attachment

1.1 Overview

Change has become a way of life for organizations, as the business environment has become increasingly dynamic. Many organizations are being forced to re-examine every way in which they can improve their performance. Workplace redesign and relocation has been used as a catalyst by many organisations to introduce many elements of organisational change. However such change can have a significantly undermine performance and can cause long term damage to work relations. For this reason, thought needs to be given to the ways such changes are perceived by employees, and the consequences of such changes [1].

Despite the best efforts of corporate managers, 25 per cent of major change initiatives fail because employees are fearful of and resistant to change [2].Most changes fail because the soft aspects of change are not properly managed. Employee resistance can pose significant obstacles to the planning and development of office space relocation, particularly for projects that attempt to change the way people work.

Office renovations and relocations are one of the most challenging aspects of a facility professional's job to resolve growth and space constraint problems in organisations. Yet, to employees, the change can be seen as threat, disturbing and emotionally alienating. These placements can have serious negative and emotion-laden consequences when seen from the point of view of environmental deprivation [1].

Many organisations are acutely aware of the costs associated with high staff turnover, staff alienation, and recruitment. The cost of not overcoming the resistance to change can be enormous [3]. The negative attitude can affect the bottom line. The Bureau of Labor Statistics estimates that U.S. companies lose $3 billion a year to the effects of negative attitudes and behaviours [4].

The research is particularly focused on the concept of place attachment to understand better the person's response to a changed environment. In particular it suggests possible mechanisms for using the work environment as a way of accelerating our sense of belonging in the new workplace. In order to combine place attachment theory with practice, the research will undertake a case study analysis in which the research quantifies and qualifies the phenomenon of employee place attachment.

1.2 The Relevance of the Research

Psychologists and others concerned with work behaviour have long been interested in employees' feelings in terms of outcomes such as satisfaction, stress and fatigue. In contrast to research on the expression of emotion, research on the experience of emotion is relatively underdeveloped [5]. Even though recent interest on affectors in the workplace has been intense, ignorance regarding the emotional significance of the physical environment remain.

Routinized interactions in a given location typically result in place attachment. An emotional bond is formed by an individual with a physical site. Having developed a 'secure' place attachment, the loss of such an attachment creates a stressful period of disruption. The move is often a ‘loss experience’ for employees. Employees place attachments often go unrecognised by management involved in such transition processes [6]. Ignoring the emotional charge given by these employees has the potential to undermine the success of the move project and the organisation itself. The focus of this research is to expose the current gaps in our understanding of 'attachment' to previous workplaces as a phenomenon.

However today, social theorists are often skeptical about the importance of place and place attachment, as people seem to be increasingly mobile, and their social relations and other experiences become disembodied from physical location [7]. Far from reducing the importance paid to physical space, the focus on knowledge work and increasing productivity in the new economy lead to more increased emphasis on creating the “right” working spaces. Although technologies have the potential to enable people to work anywhere, people still need to choose to work somewhere [8].

Much of the previous research about psychology in work environments is largely defined by the outcomes and facets of the physical environment. For the individual employee, such research has focused on the outcomes of satisfaction and performance and their association with the ambient environment. For interpersonal relationships, it has focused on the outcomes of communication and group formation, cohesion, as well as their relationship with features of the workspaces and layout. For the organisation, the focus has been on organisational effectiveness and its association with the features and layout of buildings [9].

These studies with their behaviourist approach assume that change is best achieved by considering “external” factors. For example a change agent working on these assumptions would look for those reinforcements which are producing the current behaviour. Having specified the new behaviour precisely, the object would be to set up a schedule of reinforcement to encourage the necessary change [10].On the other hand the cognitive approach is based on the belief that behaviour is controlled by “internal” factors, such as the individual’s beliefs, assumptions and theories about the situation. To change behaviour, therefore you have to change these internal theories [10].

This research is concerned with the cognitive, affective and behavioural processes which contribute to a person’s attachment with a place. Issues of place attachment, personal expectations and perceptions have a significant bearing on a person’s response to a changed environment, even when a move provides a path for economic improvement. To date, however, our understanding of how these factors relate to each other and place attachment is rather limited in move projects in organisations.

After describing the aims and objectives, the paper will reconsider previous work done on place attachment phenomenon. Empirical research findings are drawn from a broad-ranging literature review. The resulting research model will be applied to the proposed case study and the validity of this model assessed.

1.3 Aims and Objectives of the Study

Change and transition recur in the lives of people and are part of human development. Although for some people change is positive, for others it is difficult to accomplish without disruption and distress [11].

The main aim of the study is to determine the impact of place attachment in employees' perception of change. It seeks to describe the socio-psychological and behavioural effects of changes in the physical environment on employees.

The second aim of this study is to explore the meanings such adjustments hold for employees exposed to changing environments over time. And discover how these meanings influence to adopt new environment.

The third aim is to examine the extent of employees' place attachment in old and new environments. This involves isolating aspects of the person–place transactions which have affected their ability to detach from the old environment and attach to the new.

The objectives of the study are:

- To expose the current gaps in our understanding of "attachment" as a phenomenon
- To investigate human reaction to change in the environment
- To measure the significance of this reaction to business performance
- To obtain tools for communicating concepts of change management.

There are pragmatic and facilities management implications arising from the phenomenon of place attachment. Further investigation of the affective relationships that all employees have with their workplace will aid in appropriately designing and managing facilities.

2. Previous Research on Place Attachment

2.1 What is place attachment?

The psychology of place is an emerging area of research that explores the association between individuals and their immediate environment-setting. The psychology of place assumes that individuals require a “good enough” environment in which to live. People are linked to that environment through three key psychological processes: (1) attachment; (2) familiarity, and (3) identity. Displacement breaks these emotional connections. The ensuing disorientation, nostalgia, and alienation may undermine the sense of belonging and mental health in general [12].

Familiarity refers to the processes by which people develop detailed cognitive knowledge of their environs. Place identity is concerned with the extraction of a sense of self, based on the places in which one occupies in life [12].

Place attachment is the pattern of reactions that a setting stimulates for a person. These reactions are a product of both features of setting (what settings are) and personal processes (what the people bring to it) (Figure 1) [31].

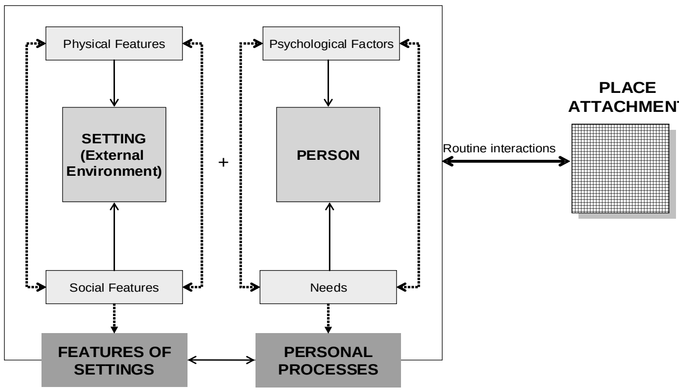

Figure 1: Place Attachment, the link of features of setting and personal processes (adapted from Steele F., 1981)

Milligan (1995) defines place attachment as “the emotional link formed by an individual to a setting that has been given meaning through interaction, comprised of two interwoven components: the interactional past and the interactional potential of the setting” [13].

The *interactional past* refers to past experiences: in other words “memories” associated with a setting. Places have the power to recall emotions and stir memories that have been dormant while the person was away from the place. *Interactional* potential refers to the future experiences imagined and anticipated to be possible in a setting, or in other words “expectations”. An individual’s experiences within and in relation to a specific setting, result in a set of expectations for future interactions in the setting.

In forming people–place interactions, what people bring to their setting is as important as the place itself. A particular setting becomes a place to an individual specifically because of the activities that have occurred within its boundaries, which then come to be associated with the setting. A history develops that is tied to the experiences of people that have occurred within the setting. At the same time, specific features of the setting shape, constrain and influence the people's perceptions and expectations for evaluating new settings [6].

Setting acts as also as a facilitator of needs. Place is important in the extent to which it satisfies a need. Stokols and Shumaker (1981) suggested that the degree to which a particular setting satisfies the needs and goals of an individual determines his or her judgement of its quality [14]. This quality judgement regulates the attachment to a place.

Within the past few years, place attachment has been studied by scholars from several disciplines such as: anthropology; architecture; family and consumer studies; folklore, gerontology; landscape architecture; leisure and recreational studies; marketing; psychology; sociology; social ecology; and urban planning. This diverse research is bringing to bear different philosophical approaches, theoretical formulations, and research methodologies. Perhaps, the most important challenge for researchers in this area of inquiry is to integrate different viewpoints and approaches [15].

Giuliani et al. (1993) group the differences in the researchers' definitions of place attachment according to several characteristics [16]:

- the content of the bond: affective, cognitive, and/or symbolic
- the valence of the bond: positive or negative
- the specificity of the bond. Some researchers choose to consider attachment as a broad concept, a super-ordinate category whereby affects are designated as part of an entire system such as 'set of feelings'. Others seem to consider attachment a specific affect that is distinct from other kinds of affects which are part of the same system.

Problems arise if we accept a broadened definition of place attachment. Such definitions of the phenomenon become so general that they fail to explicate the nature of the cognitions and affects that characterise psychological bonds, linkages, ties, and so forth with places. It also obscures the conceptual distinctions between different affective bonds and their dynamics.

As a result, the role of place in people's lives is more complex than we understand. Attachment can be viewed as a multilevel person–place bond that evolves from specifiable conditions of place and characteristics of people. This fact has implications for the attitudes and behaviours of individuals toward their socio-physical environments [17].

2.2 The Process of Place Attachment

Place attachment operates in the background of awareness. It is difficult to assess. Shock of disruption helps to clarify what has been disrupted. A study of place attachment starts with an understanding of disruptions of place attachment.

Repeated interactions in specific settings including organisational locations typically result in place attachment. An emotional bond forms between an individual and a physical site. After the development of secure place attachments, the loss of normal attachments creates a stressful period of disruption followed by a post-disruption phase of coping with lost attachments, followed by the creation of new ones [18].There are discernible patterns across the phases of attachment and disruption (Figure 2).

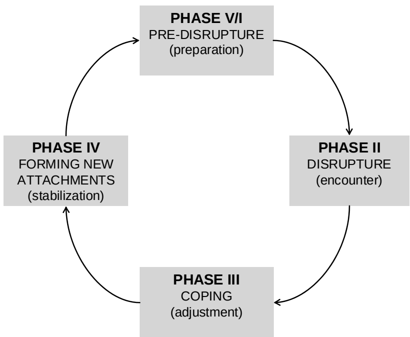

Figure 2: The transition cycle (adopted from Nigel Nicholson (1990)

Place attachments develop slowly but can be disrupted quickly and can create the need for a long-term phase of dealing with the loss and repairing or re-creating attachments to people and places. These three phases are interdependent, as qualities of the initial attachment or disruption can ease or exacerbate the stress of loss and difficulty of re-creating attachments. Much of the challenge facing those with disruptions of place attachment is to negotiate reconciliation between the past (what has been lost) and the future. Certain aspects of pre-disruption attachment may forecast the extent and severity of the disruption and the availability and effectiveness of coping mechanisms [18]. Therefore attachments are important for their long-term consequences. Place attachments are continuous and form a dynamic model of people-place bonds [16]. The most stabilised conditions contain the possibility of future change, and therefore embody varying states of readiness for the onset of a new transition cycle [32]..

There are two important studies that specifically address the process by which place attachment is formed. Fuhrer and Kaiser’s (1992) work entitled “Attachment to the home place: the emotional bases" is important as it explores the aspects necessary for the formation and maintenance of place attachment [19].

Fuhrer and Kaiser (1992) advanced the field of people–place relationships by thinking of place as a facilitator of emotional needs. They adapted Bischof's model of social motivation which suggests that "four emotions represent the core of social regulations: security, arousal, autonomy and libido. Thus, "places are experienced in terms of these emotions and represent the basis for regulating both identity and social interaction" [19]. They developed and tested a model involving three processes of place attachment. Place was described as a facilitator of emotional needs, based on the emotions of (1) security, (2) autonomy and (3) arousal. Significant relationships between social and physical qualities of the home place and of the emotional dimensions were found. The results revealed that these emotional meanings represent the bases of attachment to the home place.

Gerda Spellers' (1996) work has expanded Fuhrer and Kaiser's concepts on the aspects of place attachment, including external stimulation, emphasizing the importance of appropriation and place congruence [20]. These aspects not only seemed to lead place attachment but also play an important role in order to maintain it. However, she also argues that further research is needed to establish whether these five aspects of place attachment are apparent in other research contexts, such as work environments.

2.3 The Models of Place Attachment

Several models of people-place relationships have been put forth in an effort to provide framework for how people develop ties to places and some has received limited empirical tests.

Gerson et al. (1977) in his structural alternative model focused on attachment at the individual level [21]. They define attachment as "an individual's commitment to the neighbourhood and neighbours". This commitment takes the form of both social involvement and subjective feelings. According to this model, attachment develops as a result of an explicit cost/benefit analysis. The individual is believed to evaluate the neighbourhood based on what he or she is giving up or gaining by living there. As long as the benefits outweigh the costs, an individual feels some attachment to the area. Both people and place characteristics are considered within this comparison and contribute to attachment [22].

Stokols and Shumaker's (1981) in their model of place dependence relied heavily on Gerson et al.'s (1977) model of place attachment and extrapolating directly from Thibaut and Kelley's(1959) model of comparison level and comparison level for alternatives [23]. They hypothesized that persons may become dependent upon their current dwelling and neighbourhood through comparison process. The individual considers the number, range, and salience of needs being met by the current home, including the quality of resources available in the area, and this analysis yields a “comparison level”. The individual goes through a similar process in considering alternative places. If the current locale compared unfavourably with potential alternatives, the person was not considered to be dependent upon the current place, and was in fact more likely to move.

Stokols and Shumaker (1981) develop the concept of place dependence or an “occupant’s perceived strength of association between him or herself and specific places”. They proposed that the assessment of “strength of association” involves a two-component process, including an individual’s judgement of: the quality of current place; and the relative quality of comparable alternative places.

Stokols and Shumaker expanded their model of place dependence to include integration of satisfaction. Attachment derives from a positive evaluation of the quality of the place vis-à-vis one’s needs to what extent the environment allows certain functions to be carried out. Attachment will be all the stronger the greater the number and the more important the needs satisfied. But the basis of the model remained more cognitive than affective [24].

Stokols at al. (1983) reported empirical support for the place dependence model of person-place transactions. However dependence as described by Stokols and Shumaker (1981), can be affectively different from attachment Stokols et al. (1983), these researchers did not maintain this distinction in their empirical research. Instead they used a direct measure of attachment, as well as their measures of place dependence, to examine the effect of person-place bonds on outcomes of interest.

Prohansky (1978) took a totally different approach in his discussion of the relationship between people and places [25]. Whereas the other two models operate attachment in a functional sense with reference to places, symbolic attachment can also be found for places that have only symbolic value, which embody group identity, etc [17]. Prohansky defined place-identity as an individual’s awareness and perception of the world as represented by a collection of “memories, conceptions, interpretations, ideas, and related feelings about specific physical settings as well as types of settings”. And attachment derives from the meaning the place has for person’s identity [26]

The model does provide a useful theoretical explanation of why people may need to develop attachments or bonds to their socio-physical environments. There are problems however, with the breadth of the theory as there are very limited empirical studies to test the relationship of place to the development of self identity. In addition, Prohansky argues that place identity is both cognitive and affective; yet it is unclear how these separate systems operate in defining place identity.

The purpose of this review is to obtain an understanding of the vast volume of theoretical and empirical work on place attachment in order to clarify the relationship between and person and place and provide the background for the research design.

3. Research Design

Change is an experience which can be threatening in advance however very little is known about why change should be threatening. Personal meanings are important determinants of the impact of change [10]. A key to the meaning of place lies in the expressions that people use when they want to give it a sense carrying greater emotional charge than location or functional node.

The question which must always be raised is whether the new environment produces demands and situations which are different from the individual expects. What practices should organisations undertake to maximize the benefits and minimise the costs of the rising tide of transitions? The conceptual framework of the study aims to answer such questions.

The relocation projects provide the opportunity for a field experiment in which facilitators and inhibitors to the formation of place attachment can be identified during the whole process. As part of the British Facilities Management, Thames Valley Network, given the opportunity to study several work groups that will experience office renovation within the same facility in Nationwide Headquarter, Swindon.

The study involved a three phase-longitudinal approach conducted over an eighteen month period to monitor the process of place attachment (and detachment) starting two months before the relocation and ending sixteen months post relocation. Data was gathered primarily from in-depth interviews. However a survey instrument was also used to measure attitudes.

The case study relocation scheme was announced and accepted in July 2003 and the first interviews in phase 1 of the study, took place in March 2004, one month before relocation. The relocation followed in April 2004. The second set of interviews, I2 were undertaken in June 2004 as well as questionnaires.The timing for data collecting phases (periods) were determined by theoretical and practical considerations. After the move, the two month period was considered to be long enough for people to gain a sense of permanence and not be caught up in the frustration of practical tasks regarding the move. Seven month post-relocation was thought to allow enough time for people to evaluate the new situation about their attachments in the final phase of data collection.

A longitudinal approach was important to understand the dynamics of place attachment. It was intended to show the nature of the growth and trace patterns of change in an individual [27]. The rich data provided by repeated in-depth interviews with employees over a one year period provided an essential resource for exploring the process of change.

Several problem points can be derived from analytical approaches in previous place attachment studies:

- In place attachment studies a variety of approaches exist (either theory building or theory testing) which lack coherence
- Place attachment can be thought of as both a product and outcome (i.e. feeling attached) and a process (i.e. reasons for attachment) [24] [28]
- The existing theory on "place attachment" is incomplete and may not be applicable in all types of work environment.

The proposed model is adopted from Passini's (1992) model of cognitive mapping. Passini suggested that people cycle through a set of decisions using a process of 'matchmaking' to evaluate a decision and determine behaviour [29] [30]. As place attachment is a cognitive process, matched feedback process well explains how this mechanism works in a changing environment; people cycle through within move (before move, on the move and after move). Our expectation of a future setting is the product of our past experiences. In a familiar environment, a person recalls what should be sensed at a location and this is checked against what is actually sensed. If there is a match, then a planned behaviour is executed, as establishing new attachments. If the two do not match, it is problematic; he shows resistance to change. New approaches are needed to manage the expectations and attitudes. It is suggested that once precursors of his previous attachment are identified, they can be used as a mechanism to adapt to new situations and find the match to continue the process (Figure 3).

While defining the attachment, one should consider not only cognitive bonds which explain the operational aspect, but also the emotional and symbolic content of the bond which covers the precursor of attachments; individual characteristics influencing attachments; and characteristics of places which influence whether people attach to them. Place attachment is the pattern of reactions that a setting stimulates for a person. These reactions are a product of both cognitive and emotional/symbolic aspects of the bond (Figure 1).

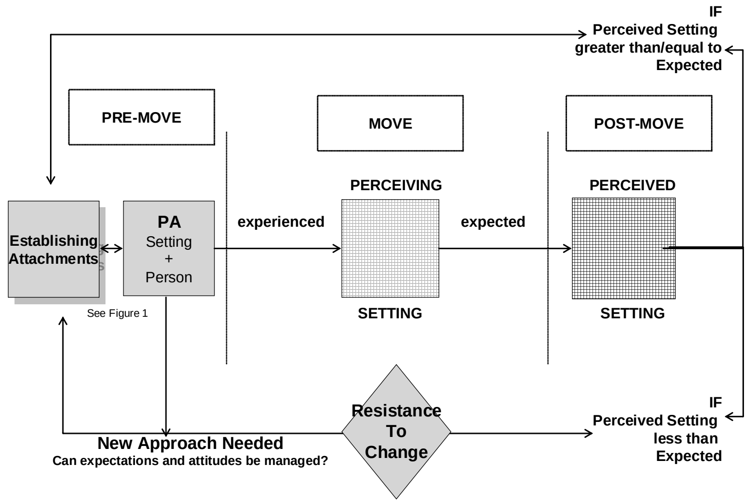

Figure 3: The proposed model-matchmaking process (adapted from Passini's (1992) model of cognitive mapping)

There have been many attempts to conceptualise the process of interacting with an environment and the role of place attachment in determining spatial behaviours. While the previous models reflect on the complexity of place attachment, they go no further in providing testable hypotheses that would stimulate research. The proposed model in this study, offers some integration of the processes, concepts, and relationships involved.

It would be wrong to suggest that previous models explaining place attachment are mutually exclusive. They place different emphasis on the importance of stability and, therefore, on the consequences of leaving a place. The proposed model takes account of this issue. While the emphasis of the research is on the emotional and symbolic bonds, a quantitative survey explaining the cognitive process of attachment would provide numerical support for the links.

4. Conclusions

The analysis confirms the presence of "place attachment" issues in the cases studied. Employees and themanagement of the department expressed concerns about this. The question raised is 'what conflicts arise between user expectations and the eventual characteristics of the new work environment?' Moreover, 'what practices should organisations undertake to minimise change resistance and to maximise the benefits of organisations connecting people through their beliefs and feelings?' The conceptual framework of the study aims to answer such questions.

It has been shown that place disruptions (move experiences) interrupt the processes that bind people to their socio-environments. In order to understand the impact of this disruption, one must examine: (1) pre-existing conditions that influence the experience of attachments, as well as (2) post disruption conditions that influence how individuals can cope with their losses and begin rebuilding ties to places and people [18]. The difficulty of coping with loss and re-constructing place attachment is that organisations rarely appreciate the depth and extent of these attachments and yet these emotional connections remain unmanaged.

Change is necessary. Without it, organisations and individuals become complacent and stale. However in managing change, the critical task is to understand how changing one element changes the rest; how sequencing and pace affect the whole structure. Achieving this critical balance means balancing new strategies whilst preserving the sense of continuity. This is achieved by managing the organisational context in which change occur and creating connections with employees. The question of place attachment has a role to play in managing the emotional connections with new workplaces. Facilities managers, designers and planners need to be aware that people become attached to place and that they are likely to encounter resistance from them. In the knowledge that place attachment is a significant part of human well-being and psycho-cultural adaptation to an environment, designers may be able to solve problems of work space design. Design elements can be introduced that nurture a sense of belonging in an organisation.

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Living environment – relation between sociopsychological and real estate aspects

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Abstract

Real estate is one of the most important elements of the infrastructure, connected with place of living and its environment. Very important parts of the living environment are the public buildings and other infrastructure, above all traffic. There are different interrelated aspects, from which real estate could be elaborated: technical, functional - physical, economic, marketing, urban, normative (ownership), ecological–ergonomic.

The main problem generally refers to the relationship between sociopsychological and real estate aspects. We were interested in: the structure of perceptions connected with different aspects of real estate in the living place and in its environment, types of public buildings and sectors of traffic infrastructure which are perceived as most worthy of financial investments; and the difference between the groups of participants regarding perception of environment and real estate aspects and regarding the perceived needs of investments into different infrastructure areas. We verified hypotheses, that perceived needs for investment differ regarding area of investment and regarding group of respondents. We expected, that evaluations of proper living environment discriminate between different evaluation of its offer.

Four groups of participants were embraced in the research: students of psychology, employees or owners of real estate agencies, people, employed in important public institutions and people with academic education from the field of building construction.

The following variables were identified in the framework of the actual research: demographic characteristics; objective characteristics of living place and its environment, connected with real estate; subjective variables, connected with living place and its environment, like evaluation of living place, its environment, the people living in the environment, the different offers located in the environment, but also the evaluation of proper working place; perceived need for the financial investments into different areas of infrastructure.

Factor analysis reduced evaluative variables, measuring perceptions connected with living place and environment. Treating the evaluations as predictors we discovered significant discrimination between two groups of respondents who evaluated the offer in their living environment: evaluation of the people, together with some evaluations of environment have the highest correlation. Friedman's nonparametric test for the repeated measures revealed the perception of investment priority, connected with traffic infrastructure, into new apartments, geriatric buildings, hospitals and youth clubs. We discovered with the Kruskal – Wallis test that public groups more than others prefer investments in apartments and engineers more than others prefer investments in swimming pools.

Keywords: environment, infrastructure, perceptions of real estates, public buildings, investments

1. Sociopsychological aspects of real estate

Different responses on environment depending on climate, self-evaluation, values, lifestyle, culture, identity and efficiency of individual could be expected by particular target samples. That can be reflected in the relation toward real estate status of the family, living place, organisation, evaluation of inheritance and nation. The life cycle of real estate has not only the nature of technical, technological and economic aspects but also is the result of different perceptions of individuals between the real estate processing. The relation is detached through the functional, living, ecological and other qualities.

The real estate market is a process of social interaction and communication which is indicated in the process of offer and demand. Real estate market research is dealing with urban experts, investors, financial experts, agents, marketing researchers, sociologists, psychologists. It contains few phases: defining market sphere, analysing economic base (sources, employment, income, population, economic trends), analysing market condition (offer and demand), projections and conclusions (intensity of demands, sort, price, market share) and analysing potential profit (regarding legally, location, physical, market, social, psychosocial, financial facts). The multidiscipline is important for people concerned with real estate, in the sense of versatility, following the legal, economic, social, cultural, architectural trends and rules. Experts should be educated at the schools (Thompson, 2002) equally on the cultural and technical level because the importance of natural and humanistic sciences is on the same level for the integral personal growth.

The main questions in environmental research are connected with interaction between environment and social behaviour, and their assimilation to changes which are caused. The interaction models between individual and environment are gathering on analyses of social variables (individual and group, personality, culture, part, organisation, social-economic characteristics) considering the influence of physical facts and variable's analyses of nature and shaped environment (characteristics of architecture and landscape, characteristics of environmental processing, sphere and frequencies of the processes). From the marketing point of view real estate could be interesting on every level of the market network, and it can have ergonomic and its ecological part (Stockols&Altman, 1991).

Macro-environment is decided with two elements of space's comprehension (Kovič, 1992): A) Space is measured in four dimensions (co-ordinates of space and time), is objective real and present. It is conditioned by the combination of elementary climate and geo-morphological components of nature and built environment. B) Space is represented in un-measurable dimensions, is subjective real. It is conditioned by the perception and spiritual field of global space with interactive influence. The built environment is exactly defined and suited for the given or perceived circumstances at a particular moment. Components of global space, which define the quality of un-measurable space, are always changing and influencing the human perception of living environment.

The town is a place in which three basic components of spatial ingredients are connected: nature space – it gives the basic shape of land, it's structure and characteristics, with water, vegetation, fawn and clime; social setting – it includes individual and community, activities, institutions, culture with customs and manners; and material products – which form the culture of the society with buildings, installations and recourses. All together are expressing the entireness of occurring and collaborating nature, beings and things in dynamic process of changing and revitalising, from which neither past, nor in development focused future is not excluded.

One of the important questions of psychological research of the environment is the interaction between the individual and environment. This concept has significance in the sense of interaction of the individual with his immediate physical environment. The word interaction means reciprocal activity or influence: environment on individual and individual on environment. An individuals influence is possible on its immediate environment, especially if we talk about two-way influence. This interactive relation was shown by Piaget (1971) with processes of assimilation (adaptation of something to oneself) and accommodation (adaptation of somebody to environment). Assimilation and accommodation are basic processes of interaction with environment. Biological views of the mentioned processes, Piaget "transferred" on the level of psychological functioning. Assimilation and accommodation have become basic processes of interaction with physical and social environment. From the view of individual psychological processes are the base for the analysis of cognitive development of individual.

Cognitive models of interaction between human and environment are dealing with questions: about the relation between characteristics of the environment and individual characteristics; about the differences in cognitive perceptions and categorisations of the physical environment, from the point of view of various social and cultural groups and their social and spatial behaviour, standpoints and stereotypes toward physical environment; and about social representations of different macro-objects and macro-events (Rus, 1997).

The integration of global and local views is significant for urban analyses nowadays. The new urban concepts are related with social changes in line of globalisation, development of informative and communicative technology, democratisation of society, ecological consciousness, energy economising and changes of life style and patterns. Slovenian towns, where the consciousness about preserving the culture in the meaning of architectural heritage exists, are uniformed under the influence of investment capital and modern designing access. Some of the objects or complexes escape from the uniformity by changing the content, the open spaces are becoming scenes for social interactions and collective identity (Dimitrovska, 2001). Rem Koolhaas (1995) has the theses of fluid and an-rational space, in which particular objects are only artefacts or substrates of urban ingredients. The final result could be only autistic in dis-functionally space. Open interactive spaces are removed from the uncommunicative and aggressive environment of streets, squares and parks to the supervised world of internet, as well as the enclosed and safe space of market centres and terminals.

2. Research problem

The problem generally refers to the relation between sociopsychological and real estate aspects. More concretely, it could be explained as the following questions: Which is the structure of perceptions connected with different aspects of real estate in the living place and in its environment? How do these perceptions discriminate between two groups of respondents, who 1/ more positive or 2/ less positive evaluate different offers, connected with the quality of life of their living environment? Which types of public buildings and sectors of traffic infrastructure are perceived as most worthy of financial investments? Do the target groups of respondents differ regarding the perceived needs of investments into different infrastructure areas?

The following hypotheses are formulated:

- There are significant differences unperceived need for investment into different areas of real estate (for example: schools, hospitals, sport halls, etc.).
- There are significant differences between four groups of respondents in perceived need for investment into particular category of real estates (for example: schools, hospitals, sport halls, etc.).

- Evaluation of the living place, its environment and of people living there (as set of predictors) significantly discriminate between two levels of criteria (perceived offer in the place of living: above and under median level).
- Perceived investments into different areas are mutually dependent, forming also independent groups (criteria of perceptions).

The research comprised four groups of participants:

- students of psychology from the Ljubljana University, Slovenia (n=25, mean age=25.80, SD=5.8, 0,9 women, 0,10 men);
- owners or employees of real estate agencies in Slovenia (n=31, mean age=43.55, SD=12.66, 0,4 women, 0,6 men);
- employees in the public sector and state institutions from Slovenia (n=24, mean age=39.20, SD=14.00, 0,6 women, 0,4 men);
- employees in the field of construction business in Maribor, Slovenia (n=28, mean age=37.36, SD=10.82, 0,6 women, 0,4 men).

Applied instruments are only a part of a comprehensive questionnaire, connecting questions about objective characteristics of real estate and correspondent perceptions (evaluations). The following variables were identified in the framework of the actual research:

a/ particular demographic characteristics;

b/ particular objective characteristics of living place and its environment, connected with real estate;

c/ subjective variables, connected with living place and its environment. All evaluations were obtained as summative scores, using the semantic differential with seven point bipolar continuums (example of one bipolar continuum: warm 1 2 3 4 5 6 7 cold).

The following bipolar attributes for evaluation of the living place, place for leisure time and work place were embraced in differential: space enough/ not space enough, dark/ shine, satisfying/ not satisfying, dirty/ clean, settled/ not settled, poor/ rich, pleasant/ unpleasant, full/ empty, equipped/ not equipped, cold/ warm, dry/ wet.

The following bipolar attributes for evaluation of the environment 1 were embraced in differential: clean/ dirty, supplied/ not supplied, cultural interesting/ not interesting, quiet/ noisy, entertaining/ boring, peaceful/ violent, friendly/ hostile, pleasant/ unpleasant, social/ not social, open/ closed, lives with tourism/ doesn't live with tourism, expanding/ collapsing, with good management/ with bad management, with good offer/ with bad offer, dynamic/ rigid, cooperates with people/ doesn't cooperate with people.

The following bipolar attributes for evaluation of the environment 2 were embraced in differential: adapted to the people with different needs/ not adapted, with enough space for everyday living/ not enough space, with efficient traffic infrastructure/ not efficient, without traffic locks/ with traffic locks, with secure traffic/ without secure traffic, with regulated parking places/ without regulated parking places.

The following bipolar attributes for evaluation of the offer in the place of living were embraced in differential: enough kindergartens/ not enough, enough shops/ not enough, sports buildings/ not enough, enough health centres/ not enough, enough cultural institutes/ not enough, enough green parks/ not enough, enough open spaces/ not enough, enough children's playgrounds/ not enough, enough leisure activities/ not enough.

The following bipolar attributes for evaluation of the people were embraced in differential: optimistic/ pessimistic, active/ passive, independent of others/ dependent, worth imitating/ not worth, exciting/ not exciting, oriented on future/ oriented on past, interesting/ uniform, not oriented on commonness / oriented on commonness, in harmony with oneself/ not in harmony, successful/ not successful, opened/ reserved, considerate/ not considerate, convinced worth of own aims/ not convinced, oriented inside/ oriented outside.

d/ perceived need for the financial investments into different areas of infrastructure: educational institutes (primary schools, high schools, university buildings), health infrastructure (into health centres, hospitals, other, geriatric centres), sport (swimming pools, skating halls, athletic stadiums), traffic(highways, railways, local roads), apartments (new apartments), culture (opera halls, theatres, museums, youth centres). Perceived need was measured on the 5 point scale (1=not needed, …, 5=needed very much).

Internal consistency for the instrument was identified for each of the four compared groups. Cronbach's alpha for each summative instrument in each group was higher than 0.80.

3. Results and discussion

Table 1: Mean ranks of Friedman's nonparametric repeated measures test: perceived need of investment into particular objects for all subjects together

	Mean Rank		Mean Rank
primary schools	8.04	highways	10.98
high schools	8.85	railways	11.08
university buildings	8.86	local roads	11.13
into health centres	8.82	new apartments	12.08
hospitals	10.46	opera halls	5.95
geriatric centres	10.34	theatres	7.38
swimming pools	8.79	museums	6.86
skating halls	5.51	youth centres	10.49
athletic stadiums	7.38		

Note. N = 89; Chi-square (16) = 275.56, p = .000.

Friedman's nonparametric test for the repeated measures revealed the perception of investment priority. The highest priority is connected with new apartments, traffic infrastructure, youth centers, hospitals and geriatric buildings. The lowest preference was discovered in the case of all infrastructure connected with culture (opera, museums, theaters).

Dwelling problem is one of the most burning problems in our country. Prices for the new apartments are very high (these can be compared with the prices in highly developed countries in Europe), supporting the financial loan system is not attractive enough for young families, on the other hand there is not enough real estate for renting which causes very high rents. So, following analyses of development prospects offered by trends in supra-regional material and immaterial communication, recollection about issues in renewal of the Slovene housing stock is becoming a very dynamic dimension (Zupančič Strojan, 2004). Conscious balancing of extreme trends and respect for multiple, not necessarily economical or natural conservation dimensions of sustainability, but also wider cultural ones in any physical scale, can help in establishing dynamic balance.

It is very interesting that perceived need of investments in new apartments, railways and local roads have the highest values. The main problem in Slovenia is the lack of an efficient public transport system in spite of the fact that new residential building are built on the peripheries of towns. Polycentric strategy of decentralisation activities, besides connecting knowledge and business innovations, includes spatial integration in the mean of urban designing and improving traffic accessibility between the towns and other countries (Pogačnik, 2000). The investments intensity is oriented in highways corridors, for which the special state programs and legislation are accepted, meanwhile the view of connecting the suburbs and other settlements near big urban centres with the efficient, attractive public transport is neglected in spite of very strong dependency of personal transports, problems with park places and pollution.

Table 2: Kruskal-Wallis nonparametric test for four independent groups and perceived need for investments as independent

areas of investment	**Mean Ranks group1 group2 group3 group4**				**Chi square (df =3)**
primary schools	51.1	43.1	47.3	51.2	1.64
high schools	57.3	37.9	48.9	50.8	6.84 #
university buildings	55.5	39.5	51.3	48.7	4.71
into health centres	53.4	38.4	48.5	47.7	4.23
hospitals	50.6	45.8	51.7	44.1	1.45
geriatric centres	44.0	53.9	52.9	41.4	0.63
swimming pools	44.3	39.2	45.4	58.9	4.34 *
skating halls	48.1	37.9	47.3	54.5	8.40
athletic stadions	53.2	35.9	52.9	48.8	5.60 #
highways	42.2	48.7	44.5	52.3	2.22
railways	47.8	47.9	42.2	50.9	1.40
local roads	46.1	49.1	50.1	46.6	0.37
new apartments	48.8	48.1	57.1	37.2	8.15 *
opera halls	46.1	44.5	48.9	47.0	0.35
theatres	51.6	39.9	49.0	47.5	2.86
museums	49.1	41.0	48.7	50.2	2.16
youth centres:	55.6	43.8	42.7	47.2	3.14

Note. N1 (students) = 18, N2 (agencies) = 24, N3 (public)= 19, N4 (engineers)= 28.
** $p < .05$. # $.67 < p < .78$.*

Almost no significant differences were discovered with Kruskal – Wallis test between the groups of respondents, two variables were discovered as important (p<0.05): investment in swimming pools and new apartments. Public group more than students, real estate agents and engineers prefers investments in apartments and engineers more than others prefer investments into swimming pools. Slovenians like sports, so it is also a country of sports champions in team or individual competitions in spite of some bad real estate conditions for training: there is not a football stadium, olympic swimming pool, or athletic stadium in our capital Investments in sports objects are needed and would also be great challenges for engineers.

Table 3/1: Structure matrix: correlation between measured variables and canonical discriminant function

	Function 1
Evaluation of the people	.67
Evaluation of the environment1	.66
Evaluation of the environment2	.58
Evaluation of the working place	.45
Evaluation of the living place	.36
Evaluation of the leisure time	.13

Note: Measured variables are summative scores.
Wilks' lambda = 0.62, Chi – square (16) = 32.14, P = 0.00.

Table 3/2: Functions at group centroids

Perceived offer	Function 1
Under Mdn	-.67
Above Mdn	.89

Note: Perceived offer is dichotomised regarding Median value.

Table 3/3: Means and standard deviations for independents – predictors for criterion »higher - lower« evaluation of the offer in the living environment

	Under Mdn		Above Mdn	
	M	SD	M	SD
Evaluation of the **people**	**50.90**	**12.16**	**62.32**	**9.08**
Evaluation of the **environment1**	**64.88**	**15.35**	**78.00**	**12.87**
Evaluation of the **environment2**	**21.39**	**7.21**	**28.93**	**7.38**
Evaluation of the **working place**	**53.76**	**11.98**	**61.22**	**8.77**
Evaluation of the **living place**	**56.10**	**12.89**	**62.35**	**8.20**
Evaluation of the **leisure time**	**60.07**	**11.83**	**62.19**	**8.22**

Note. All evaluations are summative scores, measured with semantic differential.

Particular summative evaluations, measured with the questionnaire, were treated also as predictors in discriminative analyses with perceived offer as two level criterion. We discovered, that they significantly ($p < 0.05$; $p = 0.06$) discriminate between two groups of respondents, who represent criterion variable, dichotomized regarding the median value into those, who more (above median) or less (under the median) evaluate the offer in their living environment. Evaluations of proper living place, of leisure time place have the lowest discrimination, and evaluation of the people, together with some evaluations of environment have the highest mentioned correlation. It seems, that evaluation of the offers is closely connected with evaluation of people, which may mean that investments in environment's real estate must not "forget" aspects, which facilitate the satisfying of some other social–emotional needs. The environment is laying on one side of the field of physical perception (Trstenjak, 1987). On other side exists the subjective picture of it, arising in the interactive process between the observer and the environment as a product of different experiences and sensitive perceptions

Table 4.1: Statistics of Factor Analysis

Variable	Commu-nality	Factor	Eigen value	Percent of explained variance	Cumulative %
Living place	1	1	3.56	50.9	50.9
Leisure time place	1	2	1.19	17.0	67.9
Evaluation of the environ.1	1		0.78	11.2	79.0
Evaluation of the environ.2	1		0.50	7.1	86.1
Evaluation of the offer	1		0.45	6.4	92.5
Evaluation of the people	1		0.33	4.7	97.2
Working place	1		0.20	2.8	100.0

Note. There are two components with eigenvalue equal or > 1;

Table 4.2: Rotated component matrix (varimax) for studied variables: evaluations of the living place, its environment and of people living there

Variable	Factor 1	Factor 2
Living place (accommodation)	.27	**.80**
Leisure time place	.15	**.86**
Evaluation of the environment1	**.80**	.40
Evaluation of the environment2	**.84**	.07
Evaluation of the offer	**.75**	.10
Evaluation of the people	**.76**	.36
Working place	.13	**.69**

Note: Variables are represented as summative scores, measured with semantic differential

Factor analysis reduced evaluative variables, measuring perceptions connected with living place and environment (with evaluation of working place added) into two factors, both together explaining about 70 % of variance. The first factor of the varimax rotated matrices correlates exclusively with different evaluations of the environment, including the evaluation of the people, living there and the second factor correlates exclusively with the evaluation of the living place, of the place, where somebody spends his free (leisure) time and with the evaluation of the working place. This factor may be specific for tested group(s), whose social status is characterized with shared quality of living place and working conditions.

4. Conclusions

The intention of this research was to explore the relation between the individual and real estate, and vice versa, with the aim that an investor, financial expert, urban designer would know what kind of investment are perceived as most worthy or needed, all seen from the aspects of future invests, building companies and living environment.

We can stress on the results of the research, that in Slovenia:

- The highest priority for the perceived need of investment (table 1), which is good information for investors, financial experts and building companies, is connected with: new apartments, traffic infrastructure (local roads, railways, highways), youth centers, hospitals and geriatric buildings. Perceived need of investment in educational buildings (university buildings, high schools, primary schools), into health centers and investment connected with sport (swimming pools, athletic stadiums) is in the middle. The lowest one was discovered for cultural objects (theatres, museums, opera halls) and skating halls.

- Public group more than students, real estate agents and engineers prefers investments in new apartments and engineers more than others prefer investments into swimming pools (table 2), what could be seen as challenge for engineers and designers.
- The evaluation of the offers (table 3.3) is closely connected with evaluation of people. It means that investors, social experts and designers should consider aspects, which facilitate the satisfying of social-emotional needs, while accessing the investments in environment's real estate.
- Participants separated perceptions connected with living place and environment into two factors (table 4.2). The first factor correlates with different evaluations of the environment including the evaluation of the people living there and the second factor correlates with the evaluation of the place for living, leisure time and working.

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Facilitation of Urban Renewal with Building Safety and Conditions Index

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Abstract

High-density high-rise building development is the most spectacular feature of Hong Kong's urban areas. However, fire safety and conditions of these buildings become major concern of occupants and the government as the majority of the territory's population live in high-rise apartment buildings. There is increasing pressure on maintaining the level of safety performance in buildings. The recent occasional accidents of falling concrete pieces and windows in Hong Kong have aroused public concern over the possible dire consequences of building neglect. In view of Hong Kong's growing problem of urban decay and building dilapidation, urban renewal has become a matter of great urgency.

In the current economic climate, however, budgets for urban renewal are unlikely to meet the ever-increasing needs. Although it is unlikely that this problem can be overcome completely within an injection of further resources, it is possible for the government to improve the situation by ensuring that the best solution in terms of 'value for money' is achieved in the urban renewal programme. The Building Safety and Conditions Index (BSCI), developed by the Faculty of Architecture of the University of Hong Kong, can indeed help to solve the contemporary building problems.

The BSCI is a benchmarking tool for classifying buildings in respect of safety and physical conditions of buildings. Objectiveness can be achieved in the formulation of the BSCI by adopting rigorous multi-attribute decision-making techniques such as the Analytical Hierarchy Process. Through the BSCI, occupants and the public will be informed of the safety risk associated with their living environments. In view of the monetary benefits, the building owners will upkeep their properties in serviceable conditions. For the government, the BSCI can serve as a priority setting tool to facilitate resource allocation to repair or upgrade buildings with the most urgent needs. Also, with reference to the results of the BSCI assessment, an alternative strategic solution can be achieved.

Keywords: Benchmarking; building labeling; building classification; poli; safety and conditions

1. Background

High-density high-rise building development is the most spectacular feature of Hong Kong's urban areas (Choy, 1998). In Hong Kong, there are now around 42,000 private buildings territory-wide (Housing, Planning and Lands Bureau, 2004). About one quarter of these buildings are 20 to 40 years old and are more susceptible to maintenance problems, particularly those without proper management. This accounts for about half of the residential building stock in Hong Kong. As a matter of fact, the problems of building disrepair and unauthorized building works (UBW) have long been the eyesores of the cityscape in Hong Kong, like many other developed cities. From 1990 to 2002, accidents related to UBW resulted in at least 21 deaths and 135 injuries (Leung and Yiu 2004). In addition, as the majority of population in the territory live in high-rise apartment buildings, the occupants are highly prone to hazards like fire and structural stability. Several tragic fires in recent years have illustrated the gravity of the situation. Requests for addressing the prolonged problems of inadequate building management and maintenance in Hong Kong have become more frequent than ever and any further delay to solve the problem of building neglect cannot be tolerated in any means.

In view of Hong Kong's growing problem of urban decay and building dilapidation, urban renewal has become a matter of great urgency. Urban renewal includes processes ranging from rehabilitation to comprehensive redevelopment. As advocated by Government of Hong Kong Special Administrative Region (2005), enhancing the distinctive characteristics of our territory through urban renewal, which is conducive to the development of local community economy, should be put at the top of agenda. However, upholding the public safety in respect of building conditions is costly. This can be exemplified by the recurrent expenditure of Buildings Department, which is the local authority controlling new development and existing building stocks. As shown in Figure 1, the expenditure has risen from HK$470 million in 1999/2000 to HK$743 million in 2003/2004 (Audit Commission, 2003).

In expectation, budgets for urban renewal cannot meet the ever-increasing societal needs. The problem of deferred actions for achieving better living environment which is common in many countries is resulted eventually. It is clear that increasing pressure is being brought to bear on the government resources available for urban renewal and the process of setting priorities has always been a problem for policy-makers. Although they are aware of the benefits of setting priorities, little effort has been put into the development of a systematic approach for prioritizing works.

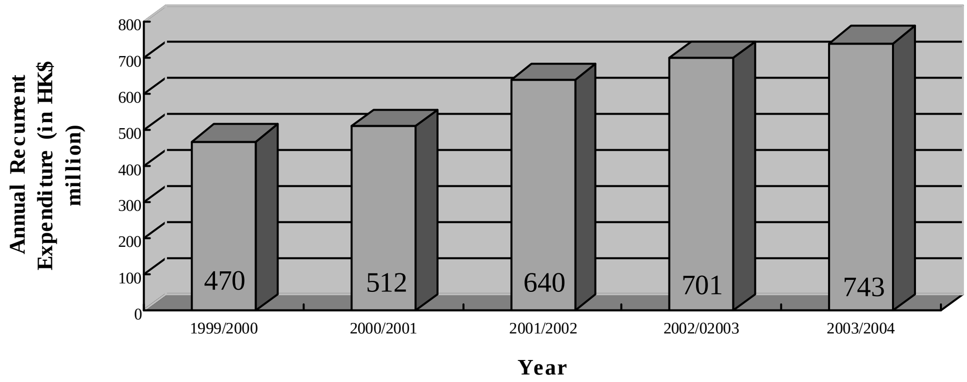

Figure 1: Annual recurrent expenditure by the Buildings Department in the past five years (Source: Audit Commission, 2003)

Therefore, there is an outcry for policy-making tool for better resource allocation for arresting the problems of building neglect in Hong Kong. Indeed, the Building introduced by Ho and Yau (2004) as a benchmarking tool for maintenance managers can help to bridge the gap. Not only can the BSCI assessment framework and the index itself promote private incentives in the upkeep of building conditions by market force, but also serves as a decision-making tool for the government. This paper studies the applicability of the BSCI for facilitation of urban renewal in Hong Kong.

2. The Building Safety and Conditions Index (BSCI)

The BSCI is a benchmarking tool, developed by the Faculty of Architecture of the University of Hong Kong, for classifying apartment buildings in respect of their safety and physical conditions in view of the need to enhance the living environment of our city. It serves to indicate the level of achievement of individual buildings in enhancing the safety of both occupants and the general public. The assessment scheme of the BSCI is backed up by rigorous and sound theoretical foundation so its creditability and practicality can be achieved. Besides, what makes the BSCI distinguishable is that its assessment framework is bespoke for the mass assessment of buildings.

2.1 Features of the BSCI

The BSCI assessment framework is intended for first-tier screening of building safety and physical conditions. Thus, a wide coverage of buildings within a short period of time at a reasonable low cost is a must. Accordingly, the assessment framework should be applicable to most apartment buildings, be they low-rise or high-rise. In addition, the factors to be considered should be directly related to building safety and conditions that pose hazards to occupants and the public. These factors should also be measurable and verifiable so objectiveness can be maintained. However, subjective judgments are unavoidable in most cases of condition assessment. In this regards, validation with documentary evidence such as record photos is necessary.

Moreover, the assessment methods should be practicable and simple, and only characteristics of buildings easily assessable by the public are acquired, measured, and assessed. Whenever possible, a building is assessed with reference to its basic configurations and conditions. On-site assessment is generally confined to common areas and the external environment only so no inspection to individual flats is required. Last but not least, the BSCI is the aggregation of the performance of individual building factors into a simple and user-friendly index for each building. For the easy consumption of ordinary people, the index can be presented in various forms such as numeric index or grades A, B, and C. Based on the index or grade, the general public can be better informed of the performance of buildings in respect of safety and physical conditions.

2.2 Construction of the BSCI

From above, the BSCI is defined and it is essentially an aggregate figure of ratings and weightings of all building factors directly related to safety and conditions of a particular building. Mathematically,

$$BSCI = g\ (w_1, w_2, \ldots, w_n; F_1, F_2, \ldots, F_n) \qquad (1)$$

where w_i (i=1, 2, …, n) denotes the relative importance (weighting) of the i^{th} building factor in affecting the safety and conditions of that building; F_i denotes the rating of the i^{th} building factor collected using the above assessment framework; n is the total number of building factors; and g is a function that combines all w_i's and F_i's. The simplest form is the weighted arithmetic mean, with all w_i's summed to unity:

$$BSCI = \sum_{i=1}^{n} w_i F_i \qquad (2)$$

2.3 Hierarchy of Building Factors

The building factors, F_i, in equations (2) have been identified through literature reviews and workshops with relevant professionals and experts. For the purposes of the BSCI, a number of safety attributes have been first made out. Fire hazard should take a place because it has long been regarded as one of the most threatening hazards to the building occupants (Chow et al., 1999 and Lo, 1999). The fire safety ranking system developed by Lo (1999) is apt for Hong Kong's situation and provides valuable guidance for identifying fire safety attributes. Yet, building safety embraces not only fire safety, but also many other factors such as structural integrity and falling objects (Buildings Department, 1997 and Choy, 1998).

Finally, eight key safety attributes, namely fire resistant construction, means of escape, means of access for fire-fighting, fire services installations, internal conditions, external conditions, density, and special hazards are identified. To come up with a practical assessment scheme for building classification, the safety attributes are decomposed into a list of building factors that can be, as far as possible, objectively measured. The building factors relevant to the safety attributes are shown in Table 1 for illustration.

Table 1: List of building factors that affect safety attributes

1. Fire Resisting Construction	5. Hazards
l compartment volume l staircase opening l fire-resisting doors	l incompatible uses l electrical installations gas installations
2. Means of Escape	6. Density
l travel distance l direct distance l discharge value l obstacles l exit and directional signs	l population per floor l number of flat per floor
3. Means of Access for Fire-fighting	7. External Conditions
l emergency vehicular access l fireman's lifts l distance between fire services access point and fireman's lift	l conditions of canopies l unauthorized building works protruding from the external walls l finishes l falling objects
4. Fire Services Installations	8. Internal Conditions
l fire extinguishers l hose reels and fire hydrants l emergency lighting	l debonded tiles l cracks l spalled concrete

The list is not exhaustive. Some strategic building management factors which apply to all safety attributes, namely management organization (e.g. deeds governing common areas, owner's corporations, and property management companies), documentation (e.g. the keeping of building records), emergency preparedness (e.g. plans for emergency situations, the provision of contingency funds), and post-occupancy evaluation systems (e.g. occupant survey), are not included. These factors should not be ignored because building safety is inseparable from building management (Choy, 1998).

For facilitating the determination of weightings of different building factors, the relationship between the safety attributes and various aspects of building factors is then mapped together to develop a hierarchy of building factors. Intuitively, poor conditions of building are attributed to misuse and the lack of maintenance. However, much literature (for example, Van Erdewijk, 1988; Heimplaetzer and Goossens, 1991 and Al-Homoud and Khan, 2004) pointed out poor design is one of the causes of building-related accidents. Therefore, building design should play an important role in building safety. In this regard, building factors are grouped into two main categories, namely *Design* and *Management* at the top level, as shown in Figure 2. Each of the building factors at the bottom level will be assessed in accordance with a scoring table, which was designed after a thorough consultation with experts in the relevant fields.

With reference to the hierarchy, *Design* factors include three categories, namely *Architecture*, *Building Services*, and *External Environment*). *Architecture* mainly deals with the provision of passive systems like means of escape and means of access for fire-fighting and rescue to protect the occupants in case of fire. Also, this category is assessed on the measures against falling objects such as the provision of utility platforms. Similar to *Architecture, Building Services*, such as fire services, electrical installations, and fuel supply, are included because their designs also have a direct influence on the safety of building occupants. As for the *External Environment*, hazards like the presence of a petrol filling station in the neighbourhood are considered. With regard to these design aspects, the safety issues of buildings can be addressed at the outset of a development project.

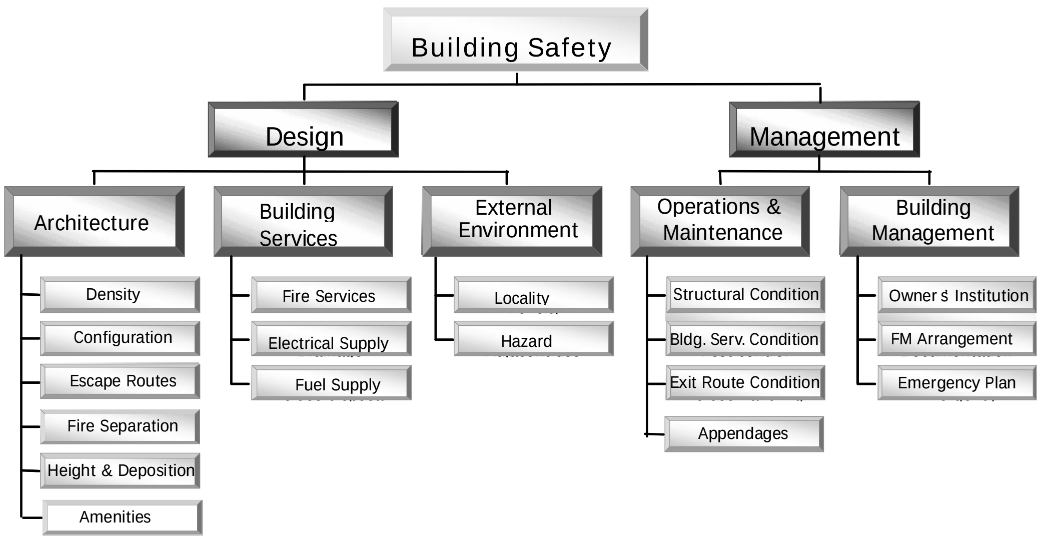

Figure 2: Hierarchy of building factors for safety and conditions assessment

Likewise, building factors under *Management* are grouped into two categories, namely *Operations & Maintenance* and *Building Management*. *Maintenance* is the inspection and upkeep of various building fabrics and services while *Operations* refers to the tidiness and integrity of the exit routes and presence of UBW in the building. *Building Management*, regarded as the software for improving the safety and condition of buildings, embraces strategic issues such as owner's institution, arrangements of facilities management, emergency preparedness, and post-occupancy evaluation.

2.4 Determination of Weightings

Step 1 — The interviewee completes the questionnaire in a laptop computer.

Step 2 — The ranking, weighting and internal consistency ratios are calculated using the computer package *Expert Choice 2000 2nd Edition*.

Step 3 — The analyzed results, i.e. the weighting and ranking of each building factor are reported to the interviewee.

Step 4 — If the internal consistency ratio in any category level is not lower than 0.1 which is the accepted level of internal consistency as suggested by Saaty (1982), the computer package will locate the likely source of inconsistency. Without influencing the interviewee's decision, the interviewee is allowed to revise their response either following the suggestion of the computer package or filling in the questionnaire again.

Step 5 — After the interviewee completes the revision in the laptop, an instantaneous feedback on the internal consistency ratio is shown to the interviewee on the computer.

Step 6 — If the internal consistency ratio is still not lower than 0.1, the interviewee can follow Steps 4 and 5 again for further revision. The process will continue until the interviewee does not wish to make any further changes.

Figure 3: Procedures of the AHP interview

Turning to the determination of the relative importance of the building factors in equation (2), multiple decision criteria systems, such as the Analytical Hierarchy Process (AHP) developed by Saaty (1982), will be adopted to calculate the weighting w_i. The hierarchal representation facilitates the assessment of the relative importance of the building factors using the AHP. Workshops are organized to interview representatives from relevant professional bodies and universities to determine the weightings of building factors perceived by these interviewees. Through a pairwise comparison of the relative importance of all factors at the same level of the hierarchy, the building factors can be prioritized. The detailed procedures of the interview are shown in Figure 3. With the use of AHP, more reliable weightings can be achieved, which is one of the most crucial aspects of the BSCI assessment framework. When all w_is and F_is are found, the overall index BSCI, which is a single measure of the performance of building safety, can be computed.

3. Applications of the BSCI

Ho and Yau (2004) stated that safety is an abstract concept which attracts diverse perceptions to different people. With the integration of people's perception with different background in a scientific manner, the BSCI provides a means of objective and widely accepted *inter*-building comparison for distinguishing the good from the bad. It serves as a benchmarking tool to measure and compare building performance in terms of safety and conditions. It is believed that a well-publicized and well-received BSCI can facilitate the urban renewal in Hong Kong. On one hand, it promotes the private sectors to voluntarily maintain the buildings by market force. On the other hand, the government can make use of the BSCI for its decision-making process.

3.1 Promotion of building care by market force

A safe home is a good one. Buildings with better safety performance should be valued higher. Other than the longevity of assets, it is because less risk premium will be paid by the potential buyers for the unforeseen problems brought about by the disrepair of the purchased properties. These buyers may risk paying a large amount of damages, ranging from approximately HK$60,000 to HK$350,000 per unit, as compensations for the victims in future building-related accidents (Leung, 2003). This amount constitutes quite a substantial portion of the average value of the units. Furthermore, well-maintained buildings may attract more favourable mortgage terms, insurance premium and rental income. However, there is asymmetric information regarding the building safety performance during property transactions. Therefore, the public places a high emphasis on the building age which is taken as a proxy for the safety performance of a building.

The BSCI now provides a useful tool for evaluating safety aspects of a building that are not easily observable. According to such previously hidden information provided by the index on how each building performs in terms of safety, the public can distinguish buildings of similar ages with different safety performances. The BSCI creates labelling effects on those better-performed buildings and these will be translated into higher property values. With a view to the prospective monetary benefits, most property owners would voluntarily exercise their management and maintenance responsibilities. With a reassessment mechanism, property owners of buildings with lower grades could implement improvement projects to their buildings in consideration of the potential monetary benefits. As empirically shown by Chau, *et al.* (2003 and 2004), improvement works brought about a substantial increase in property value which far exceeded the cost of upgrading.

At the same time, the BSCI can serve as a useful performance evaluation tool for the maintenance managers so that the continual maintenance performance can be evaluated by tracking the BSCI of the relevant buildings periodically. In other words, the BSCI can be used as a key performance indicator for maintenance services providers (Ho and Yau, 2004). The same is applicable to the developers and designers, with the incorporation of design factors in the BSCI assessment scheme. This is because higher grades obtained for their housing products or managed buildings can be a powerful marketing tool, especially when concerns over the quality of our living environment continue to surge. More importantly, the BSCI offers information on good design, maintenance and management practices. Designers and maintenance services providers can cross-check their practices with the criteria set for the scheme, and follow the practices to improve their services.

Eventually, positive recognition is awarded to well-designed, managed and maintained buildings through the BSCI. The desire of owners, developers, designers and maintenance services providers for more benefits, be in monetary terms or not, will bring market forces into play to foster a culture of building care. This would attract more resources from private sectors to be invested in the upkeep of private apartment buildings.

3.2 Decision-making tools for government

It is not uncommon for government budgets to hardly meet the ever-increasing societal needs of urban renewal. Hence, it is essential to ensure that the best solution in terms of ‘value for money’ is achieved in an urban renewal programme. The BSCI can be used as a priority setting tool for decision making and budget planning, providing a basis for allocating and directing funding to specific building-related problems. The value of the BSCI becomes more apparent when the number of problematic buildings in Hong Kong is so large and fiscal resources for urban renewal are limited and must be spread out over extended periods.

Needless to say, the grade or numeric figure of the BSCI can tell how a building performs on safety aspects. This priority setting function of the BSCI can help the government efficiently allocate resources to the areas where action is most needed. Apart from simply classifying buildings into grades A, B, and C, the government can make the full advantage of the assessment framework for decision making. Using the rates obtained from actual assessment and the hierarchy in Figure 2, scores can be for the *Operation and Maintenance* and the *Building Management*. The former reflects the existing conditions of buildings while the latter measures the potential for good safety performance to be achieved. The pair of scores of all buildings in Hong Kong can be mapped in a 2-dimensional matrix, as illustrated in Figure 4.

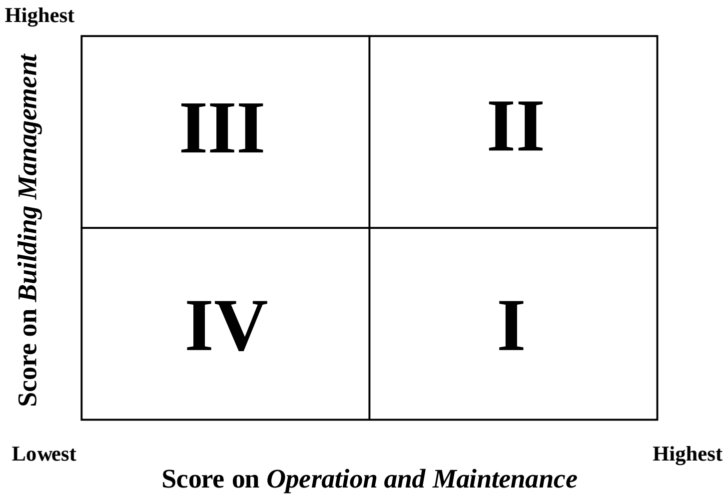

Figure 4: Connection between Operation and Maintenance and Building Management

Owners of apartment buildings with poor existing conditions but with high potential to achieve good safety performance (i.e. buildings in Quadrant III) will be encouraged to undertake improvement works to their buildings in return for higher rental or value of their properties. For buildings with good existing conditions but lacking potential for future safety performance (i.e. buildings in Quadrant I), the government should put more resources to educate the owners on the importance of building care. For instance, assistance should be given to these owners in forming owner's corporations.

Because of the lack of potential to achieve good safety performance, improvement to buildings with poor existing conditions (i.e. buildings in Quadrant IV) may not be practical. Resorts like government loan for improvement works and government-led improvement works should be opted for these buildings although the money will come from the public purse. Redevelopment may be also considered for buildings of this end. To the other extreme, the public resources to be allocated to well-conditioned buildings with potential for future safety performance (i.e. buildings in Quadrant II) should be minimal.

4. Concluding Remarks

The purpose of creating a building is to provide an improved environment for individuals, organizations, and communities (Halliday 1997). It is a common belief of ours. Paradoxically, the problems associated with building safety do not only affect property occupants or users, but also problematic results and their costs are spread across the society. Failure of the general public to undertake systematic and planed preventative maintenance to privately owned buildings has led to a substantial maintenance backlog and provided a contributing factor to the continued proliferation of unauthorized building works, incidence of canopy collapses and fatalities from fire (Choy, 1998).

Undoubtedly, these problems should be properly addressed without further delay but incremental remedies have been criticized for the lack of forethought. A long-term view and sustainable solutions should be taken. The BSCI developed by the Faculty of Architecture of the University of Hong Kong can serves these purposes. The implementation of the BSCI is beneficial to all parties. For the general public, the assessment scheme provides a useful tool for building performance evaluation. For developers, designers, building owners, and maintenance and management services providers, the information provided by the assessment scheme encourages better design, construction and maintenance of their buildings. As a result, the BSCI assessment scheme will serve to foster a culture of constructing and maintaining good quality buildings. Resources from private sectors are pumped into urban renewal. For the government, the results of the BSCI can be used as a policy tool. Such benefits become more noticeable especially during the time of government's financial stringency.

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Client’s Tool For Leading Edge Construction And Design Briefing

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Abstract

This ongoing research and development project seeks an innovative and planned approach to capture requirements in construction projects, with the purpose of overcoming the restrictions of the conventional briefing process. It aims to develop practical tools that support and facilitate understanding and implementation of client’s requirements, effective collaboration between stakeholders and create an innovative, groundbreaking briefing process. Such tools help reducing uncertainties and future problems by early consideration of issues affecting the lifecycle of a facility. Comprehensive development trends in Sweden effecting the improvement of briefing tools are described. Emphasis is on strategic briefing. Processes that converts corporate strategy into property investment or corporate real estate decisions. Processes that capture the organisation's mission, vision and values, as well as guide the process of considering alternatives that satisfy the corporate strategic direction. The project will be based on a number of empirical investigations, case studies and interview surveys among client organizations as well as development of a prototype. The results provide insight contributing to the construction client’s as well as the facilities manager’s development of competence with regard to the consequences of their selected strategy for facilitating briefing and provision of facilities.

Keywords: briefing/programming*, client, facilities management, corporate real estate, end users, stakeholders, process.

*The British concept construction and design briefing is used as a synonym to the American concept architectural programming throughout this paper.

1. The Client Briefing Tools Project

1.1 Overview

This paper reports preliminary findings of an ongoing research and development project founded by FORMAS (www.formas.se), the Swedish Research Council for Environment, Agricultural

Sciences and Spatial Planning. The project seeks an innovative and planned approach to the founding of client requirements in design and construction projects. The overall aim is to develop practical tools that support and facilitate understanding and implementation of client requirements. Furthermore, the project considers the foundation for successful management of requirements throughout the construction process and the lifecycle of the facility. The development of this briefing tools are assumed of particular interest for client representatives, project managers, development managers, developers and design managers in the real estate and construction sector.

1.2 Industrial Relevance

This R&D project is forming an organised community of people belonging to the industry, real-estate companies, and the real estate division of the county council as well as from universities [1] where the new ideas can more easily reach industry's expectations and where client's needs can be better faced, and where business problems can be thoroughly discussed.

The practical value of the project is expected as following:

- It contributes to innovative development, satisfaction and support of the client's objectives, demands and requirements of the construction sector
- It contributes to the development of the client's knowledge about the character of innovative construction briefing processes.
- It provides insight for construction clients with regard to the consequences of their selected methodology for capturing requirements and provision of facilities.
- It provides insight contributing to the construction client's development of competence
- Implementation and use of the tools in selected client organisations will be one major long term value.

2. The Briefing Process

Rezgui et al. [2] defines the briefing process as "a process running throughout a construction project by which the requirements of the client and other relevant stakeholders are progressively captured, interpreted, confirmed, and then communicated to the design and construction "team". This definition broadens the customer perspective [3]; [4], emphasizes cyclic aspects [5] and clarifies the briefing activities [6]; [7]. However, there always needs to be an avenue for stakeholders to identify, clarify, analyze, formulate, and confirm their perspectives [8] - a process with the overall aim of continually co-coordinating the client's business and facility planning.

2.1 A Strategic, Tactical, and Operative Briefing Process

Strategic briefing is a concept that has still not been completely accepted in Sweden. This basically British concept was introduced at the beginning of the 1990s to reduce the limitations experienced in traditional specification development when both public and private operations were in a state of constant change [9]. The more conventional, needs-initiated briefing process was based on the assumption that the requirements a structure must meet can be described with the help of studies of existing work processes, interviews with employees, and management.

Strategic briefing springs from the current operational needs, but also takes a longer perspective and focuses on the operation's strategic development plans, its prospects, and the building's potential for adaptation for other uses. It is a matter of identifying the activity that is to be housed in the building, how it might change, and the factors that affect these changes. Bertelsen et al, for example, found that the identification of the strategic themes is of fundamental importance for the client's possibilities to manage the construction process [3].

The tactical briefing process helps define the course of action. An operative brief considers those aspects that can be adapted and changed as the operation changes. It includes operational and building-related performance specifications, guidelines for layout, and interior design concepts that together form the foundation for the individual organisation's use of the premises.

3. Comprehensive Development Trends in Sweden - Effecting the Improvement of Briefing Tools

In 2003, twenty three in-depth semi-structured interviews were carried out with representatives from the following organisations: Swedish Cabinet Office and Ministries, the Swedish Board of Civil Aviation, Akademiska Hus AB (2), The National Swedish Property Board, the National Fortifications Administration, Specialfastigheter, County Council Property in Uppsala, Locum AB (2), the Swedish Church, SAR competition office, property consultants Jones Lang LaSalle, White Strategi architects, BSK-architects, Forum for Health Care Building, Gotland's, Malmö's, and Härryda's municipal property offices, The Swedish Pharmacy, Denmark's Radio, Swedish Posten, The Directorate of Public Construction, and Property in Norway [10]. Those chosen for the interviews had good knowledge of and experience in the sector, regularly carry out briefings, and represent different types of organisations and operations.

Each interview was recorded on tape and transcribed. The respondents were sent transcripts, which gave them the opportunity to make corrections and additions or change the content if necessary. Some of the respondents reacted with annoyance to these transcripts as they exposed the interview dialogue as it actually was. Due to this, several respondents received applicable narrative summaries of the interviews instead of transcripts from tape. In addition, some respondents had a second opportunity to react on descriptions of their experience due to balance experience and reflections over the time of approximate one year. Relevant documents supplied by interviewees were also reviewed.

The semi-structured interviews centred on descriptions of how briefing is carried out today and on what the respondents wanted to improve. A number of specific areas were covered: methods, roles, responsibilities, decision-making processes, scope, formulation of needs, and suggestions for improvements. The results that are of importance when developing briefing tools are described in the following section.

3.1 Increased Client focus, Higher Pace of Change, and Sell-off of Properties

Several factors affecting the conditions for Swedish briefing have changed in the last decade. One of these is an increased customer focus resulting in discussions on how briefs are carried out in individual projects. This was discussed on a broader perspective in terms of which building and project planning policy companies and organisations in the consulting, building, and real estate industries should follow.

Project manager at a county council-owned property company: *"As a result of the introduction of market rents, we have been forced to become more client-oriented… We have begun working on a handbook on how we can carry out a more professional strategic facility planning process."*

Project manager for a state property company: *"Our operations have been streamlined since so many project manager functions are now being bought in the market, while our briefing work has grown and has been forced to become more customer-oriented."*

Project manager for a public property company: "*The problem with our earlier briefing is that we had too little contact with the customer. The people who developed the briefs did not really know very much about the actual needs of the organisation that would use the building."*

Development manager in a property business: "*In connection with extensive sell-offs of our properties, we have had an intense discussion on the actual needs of the organisation, which resulted in more interest in analyses of the connection between the organisation and its buildings"*.

Within the private sector, an increased focus on core activities means that it is more unusual for a company to own its own premises. The briefing process is now based on a more refined user perspective rather than the owner perspective, which was used previously. The pace of change within the organisations has also increased, which means more frequent moving and shorter planning horizons. At the same time, the client is being given more formal responsibility for the management of building projects. The Swedish Planning and Building Act [11] require that the clients ensure that the work is carried out according to the provisions indicated in the law and regulations. This responsibility applies to the function, design, technical solutions, and control of the work. At the same time, many state client functions were affected by cutbacks resulting from more and more services being bought from architectural and technical consultancies. Thus, a representative for the client carries out the briefing process.

On the other hand, the interviews demonstrated that some competencies in the briefing area are often judged to be far too strategic and difficult to purchase and are therefore kept within own organisation in private as well as public sector. In addition, some respondents have expanded the strategic briefing work within their organisations. In this way, the market has contributed to a refinement of the briefing process and caused its main focus to shift.

3.2 More Inexperienced Players in the Early Stages

Several respondents pointed out that the building market has been solid in recent years, something that has also meant more building orders for one-time buyers, primarily from business and industry. As these two groups do not have much experience in the building sector, they are glad to call on consulting services for their briefing needs, which helps explain the increased demand for these firms' services. This puts even more focus on how briefing is conducted.

Some of the respondents emphasised their belief that briefing should be viewed as a strategic assignment and, for this reason, it is not part of traditional, operative project management or design work. This has also contributed to the creation of new consulting services that focus on the briefing process.

Several contractors have invested in their project development programmes to increase their expertise in managing the early stages of the construction process directly with the user as a way to provide more value for the customer as well as to make better business. Since keeping the process under control is of importance for their profitability. When the contractor takes the initiative for a project and propels it from the idea stage to operations and management, the process changes all roles of those involved. This means that the contractor must be able to inspire confidence, be sensitive to the wishes of others, and be able to identify and analyse the clients' needs.

3.3 The Need for Clear and Precise Concepts in the Briefing Phase

The absence of concepts and an established language for the briefing phase was identified as a problem by the majority of respondents. Several apply designations that the KBS (The Swedish National Board of Public Building) formulated in its time during the 1970:ies and 1980:ies, although, in practice, the designations are individually interpreted and used in various ways, while others have developed their own concepts. When the concepts for and within the briefing process are vague, communicating with users and the organisation's representatives can be a significant problem.

Developer: *"There is no common language. During the design phase, we have a lot of technical terms. When we talk about detail design, everyone knows what that is. When we're in the design process, everyone knows what the various phases demand and when the deadlines are. But there is no common language for the briefing phase. It has not been defined?'*

Some of the property owners and their representatives who were interviewed solve the problem by doing much of the work that the client or tenant, who was intimately involved in the implementation, should have been responsible for, while others solve the problem by hiring special project secretaries within the property development company. They have knowledge of the industry and the technical terms that are used in the building project.

3.4 Different Types of Briefing Processes

The respondents work with different types of briefing processes to which they also assign different names. In addition to using designations from the National Board of Public Building, they also use the definitions that are sometimes found in urban planning, and company and operations-specific guidelines. At times, the same briefing data are used for other purposes in a reworked format. Several of the respondents voiced concern over the fact that there are no applicable guidelines or a concordant vocabulary for the different kinds of briefings and for what the different categories of briefings should include, even if most of them say that they know what the different types of briefings can be expected to include.

3.5 Unclear Areas of Responsibility for the Brief

A good number of the respondents would like to have a clear definition of roles and the division of responsibility in the building sector in general. Several respondents felt that it is more important than previously to clearly define the role of the different parties involved during the briefing phase.

Administrator: *"Off and on during the goal discussions, areas of responsibility are created that are supposed to determine who is responsible for what, but they can hardly cover all situations".*

There was consensus that an unclear, decentralized division of responsibility runs the risk that responsibility for the briefing process will fall between the cracks and that this ambiguity can diminish competency in the area in the long run.

The majority of the respondents have experienced difficulties when they ask their tenants for descriptions of the operations and needs and other information that serves as the foundation for the briefing process.

Briefing architect: *"One can hardly expect the people who represent buildings and furnish operational-compliant buildings to know everything about their tenants' businesses. Just as the business representatives cannot be expected to know the types of information required for a briefing process".*

Property owner: *"We try to make it clear that this is the tenants' facility planning programme. This information serves as input for our design work, our orders. The tenant is responsible for working out a plan for his facilities. We try to be a little 'overly' clear here. I think this is good and necessary, so we know who is responsible. Tenants have to understand that if what they say is wrong, then things wont turn out as they want".*

In those cases in which the information on the business was reported, some of the respondents expressed concern over uncertainty regarding the agreement between the various people who submit information. It was indicated that the consultants hired to carry out the briefing process were sometimes far too dependent on the view of the operations presented by those submitting the information.

Several respondents also expressed concern over a lack of understanding in user groups of the briefing process's requirements in general and the time required for its execution in particular. There was very little understanding regarding the fact that the briefing requirements must often be discussed for sometimes even several years before a satisfactory result is achieved.

All the respondents believe that a well-executed operations description is the basis for a successful briefing needed for an integrated business development and strategic facility planning process.

3.6 Applied Briefing Process Methods

Briefing processes have been part of the organisations used in this study for a long time, and several of those interviewed have had a good deal of experience with this type of work. Many also worked with similar assignments at the former National Board of Public Building. Work methods that were applied on the board are still used to a great extent within private consulting firms, tenant organisations, municipalities, county councils and governmental departments. Methods have been adapted to current operations and it was felt that they worked well during a period of transition.

However, trends and developments within the respondents' own organisations call for clarification and articulation of the briefing's function.

Reasons for change is the increased demand for briefing formulation, including a move to greater client focus with clearer responsibility for long-term profitability from investments. Other trends mentioned include new formats for the briefing process—with more influence from private sector clients and developers—that have already been tried in a number of municipalities. Other types of agreed-upon briefing plans, such as supplements to land use agreements, are also being used. In this manner, the interface between the municipal detail planning regulations and the individual client's briefing process is changing. Increased understanding of the briefing process's strategic importance, the need for an accountable quality system, an aging staff heading toward retirement, and the need to transfer knowledge before the older members of the staff retire were also given as factors on how and to what end briefing processes should be conducted in the future.

On the whole, the respondents believe this development is a positive one. Many feel that the previous routines were often undeveloped, poorly adapted to customers, and far too often based on personal experience. Other disadvantages include lack of comprehensive overview and difficulties in making use of positive experiences.

Project manager in the early stages: *"We knew that our colleagues were collecting a lot of useful briefing documents - good examples. On the other hand, there was no survey or knowledge of how the documents were related to one another, which explains why we have recently begun work aimed at describing the entire briefing process"*.

Some property owners also expressed a self-critical attitude and admitted that, as of now, they have not actually worked out any briefing process methods. However, other managers have already begun to renew their methods for the early stages in the building process from a business-like and client-focused strategic facility planning perspective.

3.7 The Need for New Ways of Working that Generate Constructive Thinking

Several respondents emphasised the importance of creative and constructive thinking as the basis for a successful briefing process. Some went so far as to maintain that it is absolutely decisive and that they are looking for ideas and suggestions on how to implement this mode of thinking.

Client: *"We are looking for good examples of how to get an early dialogue started, tricks of the trade and other methods for taking the initiative. We want to find out how to capture the good ideas, make contact in the right way, how to initiate a process so that, when time is of the essence, we are not forced to do something that everyone can see will be bad"*.

The interviews are replete with observations from those responsible for the briefing process on the difficulties of balancing a favourable work method with daring to critically examine the operations with the purpose of elucidating priorities and actual needs. This was viewed as a sensitive balancing act that is difficult to manage, both for those who manage the briefing process and those who are part of the business or organisation that will use the facilities.

Property owner: *"If the process is experienced as being wrong, then it stays in a tenant's memory for a long time. That is not good, either for us or for them, and particularly not on the threshold of a long-term rental relationship"*.

Several of the respondents imply that it is good for individual projects to have as thorough and detailed a briefing process as possible, but when the organisation is questioned in an attempt to attaining this detailed description, this can be experienced as a potential threat to social relationships and the desire for continued, open discussions. The more clarifications and questions with the intent of achieving a better brief, the more situations arise that can lead to disagreements that, in turn, lead to difficult decisions.

The formulation of goals and needs that arise in consensus are experienced as easier to carry out than those that arise because someone was forced to compromise. It was stressed that more general goal descriptions can act as the instruments that hold a briefing process together over time, even if the goals are difficult to objectify in the actual project.

Everyone agreed that trust is a prerequisite for a constructive specification development process. It is required in order to access the right specification information. There also has to be trust that the individuals conducting the briefing process are competent and have the experience and authority to carry out the assignment. In addition, trust is needed so that people are able to vent their disagreements and priorities in periods of uncertainty without running the risk of a deadlock.

Client: *"The briefing process should take place in a safe environment so that people can communicate, and this has to do with trust. People shouldn't be afraid of making fools or themselves or saying something that's wrong. Not drawing quick or drastic conclusions from something someone has said. These are a few of the personal qualities that are extremely important for making this process work. If there is no trust, then there will be 'attitude' and people 'taking stands'. People notice this kind of behaviour immediately"*.

According to the respondents, the need for a creative and constructive briefing process is both fundamental and complicated. Points of departure focus on relationships, balance between comprehensive and more detailed attitudes, management of insecurity, and different types of trust.

4. Discussion and Future outlook of the R&D project

The findings from the interview study regarding the standing of the construction client and the tools he/she utilises will be combined with the results of an ongoing questionnaire (mars - april 2005) in order to provide a deeper understanding of the mechanisms that are fundamental for the clients' innovative management of projects for the provision of facilities. A presumption is that methodologies and tools could be for example quality function development, problem structuring methods, group decision-making techniques or computer based tools such as database applications and spreadsheet packages. A basic assumption for this study is also that the client today is forced to utilise too production-oriented/process-oriented tools during a project involving the provision of facilities. To focus on the perspective and activity of the construction client, instead of the internal interests of the construction sector, means that attention is shifted from discussions about misinterpreted demand formulations and shortages regarding quality of the building as a project to the prerequisites for developing the clients' competence and management methods. This is in order to allow the client, in the best possible manner, to be able to influence that the outcome of a project is in agreement with its strategic intentions. A perspective that not only focuses on the design and content of specific demands or documents, but that also aims for deeper change with regard to the praxis of the construction industry.

A questionnaire based method will be applied with the purpose of accounting for the following:

- What the client's tools are, as well as the choice of established tools in relationship to new concepts.
- Verification of factors that a tool has to support or/and if there are other factors that are more relevant?
- The client's decisive choices before and during a project involving the provision of facilities.
- What administrative and organisational processes influence the construction client's possibilities regarding the management of a project involving the provision of facilities?

The gathering of information is primarily via a larger number of questionnaires (approx. 100) with a systematic choice of representatives from Swedish construction client organisations. The forum for cooperation between state-owned property boards and real estate management (Samverkansforum för statliga byggherrar och förvaltare), as well as the Swedish association of construction clients' (www.byggherreforum.se) network and membership register is utilised for the choice of respondents. In addition to this, the relevant documentation and other written sources will constitute the empirical basis for the following of this R&D project.

5. Conclusions

Even if one should be cautious about simplifying the results from the interviews, there are some basic points that are vital for support of the client's briefing:

Briefing tools should:

- facilitate communication and shared understanding of the client's targets with regard to a facility-provision project, but also act as an engine for capturing, preparing and identifying strategic, tactical and operative information and requirements.
- include systems for regularly following up agreed brief assignments and not just final targets. This creates a better possibility of early capture and rectification of things that are unclear.
- be user-friendly and contribute to more active and creative participation on the part of everyone – not least the client as well as less experienced players

- facilitate structuring and prioritisation of the client's requirements.
- support discussions about alternative conceptual and possible solutions.
- support a translation of the client's picture of requirements into measurable requirement formulations.
- simplify verification that the brief's (detailed design brief) requirements are satisfied in the planned solutions as well as deal whit responsibilities.
- deal whit change management
- support both solution-neutral functional descriptions and technical specifications of the client's wishes with the aim of establishing creative conditions for planners to generate physical conditions that best support the client's business targets.
- support different kinds of briefing processes, such as strategic, tactical and operative briefing.

It is advantageous if briefing tools contribute towards better understanding and integration of the client's requirements on the basis of a customer-oriented approach. The tools should contribute towards more explicit definitions and improved communication of the client's requirements and expectations with regard to a facility planning project, so that connections with overall business targets are strengthened.

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[1] A reference group attached to this project includes following contributors: Sven Fristedt, professor in briefing processes, School of Architecture, Chalmers. Bo Törnkvist from Vasa-kronan, a real-estate company specializes in commercial premises, owned by the Swedish state. Harald Pleijel, from The Church of Sweden, Real Estate department in Gothenburg, that supports and maintains the national Swedish church with suitable planned facilities. Klas Lindgren, from The Real Estate division of The County Council of Östergötland (LFÖ). Their mission is to manage the public sector estate and facilities management (efm) services - from strategic estate strategies and the planning of buildings to meet the modernisation of clinical services, through to the concept of the well-serviced hospital - creating an environment that provides front line support to patient needs. Hans-Åke Ivarsson, from Lokalförsörjningsförvaltningens (LFF). LFF's principal mission is to supply Sweden´s second largest city, Gothenburg with the necessary premises for child care and education.

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Valuing Productivity Loss due to Thermal Discomfort

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Abstract

Thermal discomfort may decrease productivities. This paper derives the economic principle of assessing the market value of such productivity loss based on standard economic principles of the Marginal Productivity Theory. These losses are expressed in terms of proportional losses in economic rents and profits. This paper aims to provide a basis for systematic market valuations of losses due to thermal discomfort, and hence varying strategies under varying circumstances.

Keywords: Productivity loss, thermal comfort, predicted mean vote (PMV), marginal productivity theory.

1. Introduction

Adbou and Lorch [1994] verified that the productivity of occupants is greatly affected by the thermal comfort. Wyon [1996] and Kosonen and Tan [2004] make significant contributions to human thermal comfort. Quantitative relationship between the productivity level and Predicted Mean Vote (PMV) is now defined for some activities. This finding has a great impact on air-conditioning control. Market data and Simulations of PMV changes under varying air-conditioning control systems of buildings at different locations will be investigated.

2. Marginal Productivity Theory

Thermal comfort affects the productivities of staff working in an office.

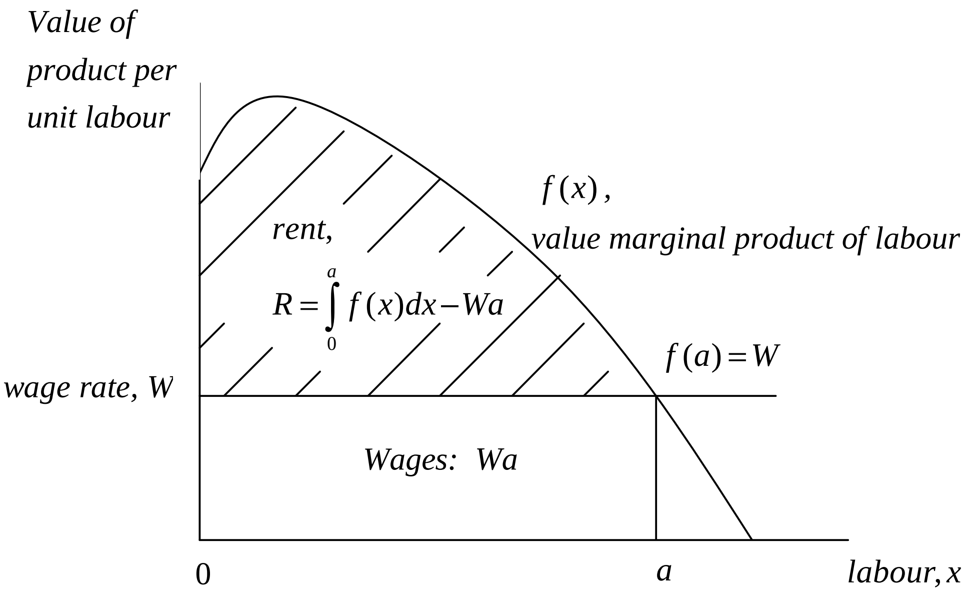
Suppose the value marginal product of labour is a function f of the quantity of labour input x. This function f is a decreasing function of x according to the Law of Diminishing Marginal

Productivity (see, for instance, Stigler [1966]). Standard economics would illustrate that maximum economic rent, *R*, could be receivable at *a* units of labour input into production, where *f(a)=W* , the competitive wage rate. And the maximum economic rent:

$$R = \int_0^a f(x)dx - Wa \qquad (1)$$

Graphically, rent is the area under *f(x)* from *x=o* to *x=a*, less wages *Wa* :

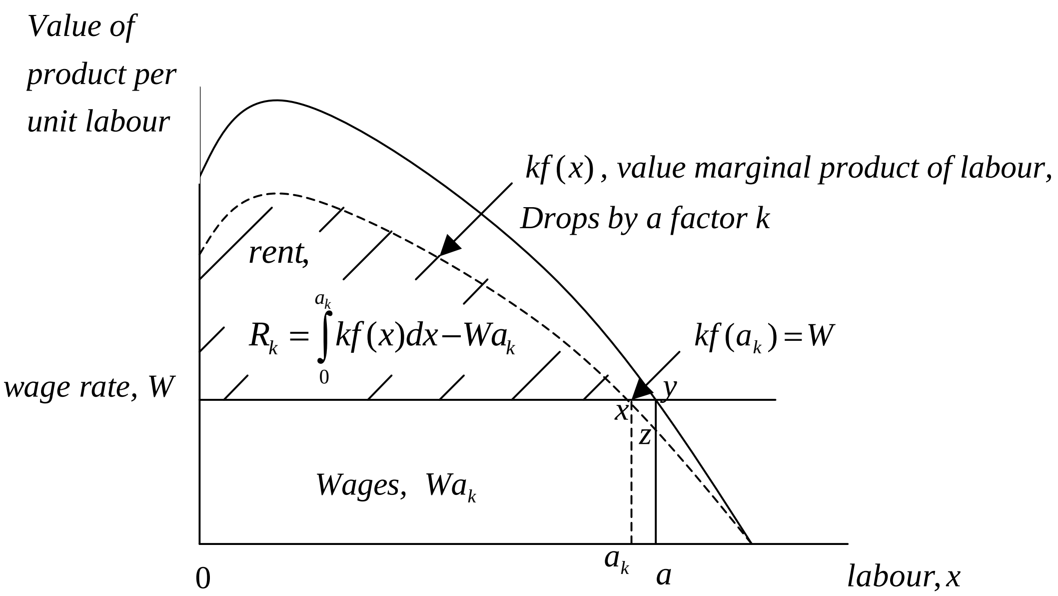
Graph 1: value marginal product and rent



3. Productivity Drop

Now suppose a change in temperature has resulted in a reduced productivity, say *k* times the original value marginal product *f(x)*. For instance, *k= 0.9* means a 10% drop in the output product *f(x),* at any quantity of the labour input, x. Then graphically, *f(x)* becomes a "10% lower" curve at every point labour input:

Graph 2: A drop in productivity



A smaller productivity would imply smaller profits, and therefore, economic rent: $R_k < R$, and

$$R_k = \int_0^{a_k} kf(x)dx - Wa_k \tag{2}$$

Since k and R are readily available data, we may estimate R_k *using* k and R.

Firstly, from Equation (1), we may re-write kR as:

$$\begin{aligned} kR &= k[\int_0^{a} f(x)dx - Wa] \\ &= \int_0^{a} kf(x)dx - kWa \\ &= \int_0^{a_k} kf(x)dx + \int_{a_k}^{a} kf(x)dx - kWa \end{aligned} \tag{3}$$

Comparing this to R_k in Equation (2), and adding terms $-Wa_k$ and $+Wa_k$ to this Equation (3), in order to allow sufficient components for R_k, we have:

$$kR = \int_0^{a_k} kf(x)dx - Wa_k + \int_{a_k}^{a} kf(x)dx + wa_k - kWa$$

$$= R_k + \int_{a_k}^{a} kf(x)dx + Wa_k - kWa \tag{4}$$

Graphically, the term $\int_{a_k}^{a} kf(x)dx$ is the area $a\ a_k\ x\ z$. Assuming the line segment $x\ z$ is reasonably close to a straight line, then this area is reasonably close to:

$$\int_{a_k}^{a} kf(x)dx \cong W(a-a_k) - \frac{1}{2}(a-a_k)(1-k)W$$
$$= W(a-a_k)(\frac{1+k}{2}) \tag{5}$$

Putting this into (4):

$$kR = R_k + W(a-a_k)(\frac{1+k}{2}) + Wa_k - kWa \tag{5}$$

After rearranging,

$$\frac{R_k}{R} = k - \frac{(1-k)(a+a_k)}{2} \cdot \frac{W}{R} \tag{6}$$

When the reduction of labour input due to a drop in productivity is negligible, i.e. $a \cong a_k$ (or, in other words, the employer finds that the drop in productivity does not justify a labour cutting exercise), then

$$\frac{R_k}{R} \cong k - \frac{Wa}{R}(1-k) \tag{7}$$

This means the ratio of reduced profits (or more accurately economic rent) to the original, R_k/R, could be approximated by the ratio of reduced productivity to the original, k, less the corresponding drop, by the factor (1-k), on the wages-to-rent ratio (Wa/R).

Equations (7) could therefore be used to estimate the loss in profits, given data of rent, wages, labour employed, and reduction of productivity loss due to thermal discomfort. If the loss in productivity is so significant that the employers have to cut staff, due to significant reduction in income, then Equation (6) should be used instead.

This implies that if wages is large compared to economic rent, i.e. Wa/R ratio, economic rent (profits) would reduce at a ratio greater than that in productivity loss: R_k/R much smaller than k. In simple words, the larger the labour costs, comparing to business profits, the greater the effects (of productivity drops) on profits.

4. A Numerical Example

Suppose there are two small offices, one a stocks broker at the Central Business District of Hong Kong; and the other, an engineering consultant in the sub-urban area. Both offices occupy 1,000 square meters of usable floor area. The CBD one costs \$12,000/m2 yearly to rent; and the sub-urban one, ten times less: at \$1,200 /m2. The stocks broker pays higher wages to its staff, around \$5 million a year; and the engineering consultant, \$3 million. Gross profits for the stocks broker, before wages and office rental, is \$7.5 million; and the engineering consultant, \$3.5.

Table 1. The stocks broker vs. The engineering consultant

	Symbol	Stocks broker in the CBD	Engineering consultant in the sub -urban area
Office size	s	100 m^2	100 m^2
Yearly rent /m^2	y	\$12,000/m^2	1,200/m^2
Yearly rent payable to the landlord	$y\ s$	\$1,200,000	\$120,000
Gross profits (before wages and office rental)	$G = \int_0^a f(x)dx$	\$7,500,000	\$3,500,000
Yearly wages	Wa	\$5,000,000	\$3,000,000
Economic rent (after wages but before office rental)	$R = G - Wa$	\$2,500,000	\$500,000
Net profit	$\Pi = R - ys$	\$1,300,000	\$380,000
Wages–to-Economic Rent Ratio	Wa/R	2	6
Ratio of reduced economic rent to original, if *k=0.9*	$\frac{R_k}{R} \cong k - \frac{Wa}{R}(1-k)$ from equation (7)	0.7	0.30
% Loss in economic rent	$l = (1 - \frac{R_k}{R}) \cdot 100\%$	30 %	70%
Reduced Economic Rent	R_k	\$1,750,000	\$150,000
Net profit after productivity drop	$\Pi_k = R_k - ys$	\$550,000	\$30,000
Loss in net profits	$\Pi - \Pi_k$	\$750,000	\$350,000
% Loss in net profit	$(\frac{\Pi - \Pi_k}{\Pi}) \cdot 100\%$	58%	92%

Table 1 shows that the net profits, after all wages and office rentals, are \$1.3 and \$0.38 million respectively. Now suppose that productivity drops by 10% due to thermal discomfort. Equation (7) allows us the estimate the profit loss due to such drop in productivity. The results in Table 1 show that the engineering consultant suffers from a much bigger % loss in net profit, 92% vs. 58%. The stocks broker's absolute loss in profit is, however, larger: $0.75 vs. $0.35 million.

Absolute loss in profit depends on the base, of the original profit, and the office rental due to location. Such conclusion cannot be easily generalized to all other examples. However, Equation (7) shows that the ratio of the reduced economic rent to the original, R_k/R, is always a negative function of *Wa/R*: the wages to economic rent ratio. Systematically plotting k, the proportion of the reduced productivity to the original, against *Wa/R*, we have the following Table 2.

Table 2. The Sensitivity of R_k/R to k and Wa/R. (the stocks broker; and # the engineering consultant)*

	k **: the proportion of reduced productivity to the original**									
***wa/R*: wages–to -economic rent ratio**	**0.95**	**0.90**	**0.85**	**0.80**	**0.75**	**0.70**	**0.65**	**0.60**	**0.55**	**0.50**
	Rk/R: **the proportion of reduced economic rent to the original**									
0.500	0.93	0.85	0.78	0.70	0.63	0.55	0.48	0.40	0.33	0.25
1.000	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.00
1.500	0.88	0.75	0.63	0.50	0.38	0.25	0.13	0.00	*(0.12)*	*(0.25)*
2.000	0.85	**0.70***	0.55	0.40	0.25	0.10	*(0.05)*	*(0.20)*	*(0.35)*	*(0.50)*
2.500	0.83	0.65	0.48	0.30	0.13	*(0.05)*	*(0.23)*	*(0.40)*	*(0.57)*	*(0.75)*
3.000	0.80	0.60	0.40	0.20	0.00	*(0.20)*	*(0.40)*	*(0.60)*	*(0.80)*	*(1.00)*
3.500	0.78	0.55	0.33	0.10	*(0.13)*	*(0.35)*	*(0.58)*	*(0.80)*	*(1.03)*	*(1.25)*
4.000	0.75	0.50	0.25	0.00	*(0.25)*	*(0.50)*	*(0.75)*	*(1.00)*	*(1.25)*	*(1.50)*
4.500	0.73	0.45	0.18	*(0.10)*	*(0.38)*	*(0.65)*	*(0.93)*	*(1.20)*	*(1.47)*	*(1.75)*
5.000	0.70	0.40	0.10	*(0.20)*	*(0.50)*	*(0.80)*	*(1.10)*	*(1.40)*	*(1.70)*	*(2.00)*
5.500	0.68	0.35	0.02	*(0.30)*	*(0.63)*	*(0.95)*	*(1.28)*	*(1.60)*	*(1.92)*	*(2.25)*
6.000	0.65	**0.30#**	*(0.05)*	*(0.40)*	*(0.75)*	*(1.10)*	*(1.45)*	*(1.80)*	*(2.15)*	*(2.50)*

Negative figures (in brackets and *italics*) in this table show cases of negative economic rents, due to substantial reduction in productivity. These are cases in which reduction of profits are so high that such profits could not even to cover operating costs and wages, not even before paying the landlords the office rentals.

We may also see from Table 2 that for any reduction of productivity due to thermal discomfort, *Rk/R* is monotonically decreasing for increasing values of *Wa/R*: the wages-to-economic rent ratio. *In other words, ignoring office rentals payable to the landlord, profits decrease more rapidly for offices where ratios of wages to profits are high*.

5. Conclusions

We started off by deducing the relationship between reduced economic rents to productivity drop due to thermal discomfort, based on the standard marginal productivity theory. We then deduced that the ratio of the reduced economic rent to the original, *Rk/R*, is a function of the proportion of reduced productivity, *k*, and the wages-to-economic rent ratio *Wa/R*: as stated in Equation (7).

This relationship allows us to estimate the reduction in profits due to productivity loss, using data of wages and gross operating profits, which are readily available in a normal office. Numerical and sensitivity analysis concludes that the profits before rental payments (i.e. economic rents) decrease sharply for cases where the ratios of wages to such profits are high.

Such rules of thumb allow the decision maker to (a) to estimate the potential profit loss when a drop of productivity due to thermal discomfort is causing alarm; and (b) whether or not to rectify the problem, given the costs of the rectification. This could be done by simply comparing the potential profit loss to the potential cost of installing sophisticated equipment to monitor and control the indoor environment. Further development along these lines, to develop practical tools of implementation, is expected of the next stage of this research.

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Section V

Sustainability in facilities management

The Valuation and Appraisal of Sustainable Development

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Abstract

The property market continues to be unsure about the benefits of environmentally sustainable development and accordingly it is not usually reflected in the property valuation and analysis process. Using the concepts of price and worth, an outline valuation process is developed to assist the valuer to take environmentally sustainable development into account through rent, capital growth and psychic income. Research has shown that lessees are prepared to pay a higher rent for improved comfort and control of the environment. Analysis of market evidence has shown that a psychic element of income can increase prices paid for properties by reducing the initial yield. Taking elements of return including higher rental rates payable by tenants and firmer capitalisation rates acceptable to landlords into account together, it is shown that a property exhibiting the highest environmental design and management principles can achieve a substantially improved property investment worth. These remain to be reflected in the general approach to estimates of market price.

Keywords: price and worth, psychic income, income approach, market sentiment, sustainable development

1. Introduction

The principle of environmental sustainability "implies using natural resources in a way which does not eliminate or degrade them or otherwise decrease their usefulness to future generations, and implies using non-renewable natural resources at a rate slow enough as to ensure a high probability of an orderly societal transition to new alternatives" [1]. The World Bank has used the phrase "development that lasts" in this context [2].

The process of sustainable built asset management is continuous throughout the life cycle of the property. The life cycle comprises "consecutive and interlinked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal" [3]. In the context of property and construction, it is a time horizon which commences with the acquisition of land, includes the design and construction of buildings, and continues with the ongoing operation of the property and ceases with the ultimate demolition or deconstruction and recycling of the property.

In Australia, buildings are responsible for 30% of all raw materials used by society and they consume more than 40% of all energy produced causing more than 40% of all air emissions [4]. Development will not be sustainable if the economic constraints under which the property development process operates are not considered. There is a common perception that there is no demand or support for sustainable development. However, the impact of buildings on the environment requires that the property and construction industry contributes to the ESD culture.

The relationship between benefits and costs is commonly assumed to be an impediment to the uptake of sustainable development. The property and construction industry and its clients tend to focus on short-term gains rather than long-term savings or investment opportunities. Perceived higher initial construction costs and maintenance costs are major obstacles, as they reduce profitability. The anticipated additional cost of ESD features is a reason for the perceived indifference of clients to environmental issues.

In Australia, concern for initial costs is reinforced by the involvement of a number of actors in different phases of building delivery, from development, ownership to occupation of structure. Energy efficiency, for example, is not considered a high priority for potential tenants and the emphasis industry puts on initial costs versus life cycle costs militates against ESD considerations.

Inappropriate financing models or lack of access to capital discourages investment in sustainable buildings. There is also no incentive to act, when often the investor is not the ultimate user who is responsible for energy bills. In addition, energy, like other business related expenses, is tax deductible and the plant and equipment that uses energy is can be depreciated against taxable income. Lenders of capital neglect environmental costs in their assessment frameworks.

The property market continues to be unsure about the benefits of environmentally sustainable development (ESD) and accordingly ESD is not usually reflected in the property valuation and analysis process. Using the concepts of price and worth, an outline valuation process is developed to assist the valuer to take ESD into account through rent, capital growth and psychic income. Research has shown that lessees are prepared to pay 5% to 10% higher rent for improved comfort and control of the environment [5]. Analysis of market evidence has shown that a psychic element of income can increase prices paid for properties by reducing the initial yield [6]. Taking all of these elements of return together, a property exhibiting the highest environmental design and management principles can achieve a substantially improved property investment worth. These remain to be reflected in the general approach to estimates of market price.

It is common for investment valuations to be prepared in association with market valuations the former by DCF and the latter by capitalisation. It has been common to adjust the investment variables in the DCF so that both methodologies provide the same result. This tends to suggest that price and worth are identical (which would be so in a fully informed market in equilibrium and is certainly so for a buyer in that market). But reference to any of the financial markets dispels this notion; transactions occur as a result of differing opinions about price and worth and this is of significant relevance to property.

Sales evidence may be analysed and its results used to value a comparable property in the normal way. But this reflects what the market has been paying for comparable properties; it does not necessarily reflect the normative solution, i.e., what it should have been paying.

First, the paper briefly reviews the findings of a sample of the empirical research in which the costs and benefits of ESD are detailed. Second, the residual analysis methodology adopted for the purposes of this paper is briefly described. Third, the data used in this paper are recorded including current market data. Fourth, the calculations are illustrated using the conventional residual model. Finally, some concluding comments are offered together with some suggestions for further research.

2. Background

Conventional business case decision making tools can be used to evaluate ESD buildings, but they have generally not been used, or used inappropriately. ESD buildings by their nature must be considered over the entire life span of the development, not simply the design and construction stage. Therefore, a whole of life or life cycle cost approach to the evaluation of ESD buildings is appropriate. In simple terms, this is because increased investment in sustainability features of building design can be offset by reduced running costs and potential productivity gains during the occupation of the building. Concentration predominantly on increased capital costs of development for ESD buildings, and use of static business case analysis tools which support this view, leads to inappropriate or inadequate consideration of the total development.

The presumption that ESD buildings “cost more” needs to be considered further. The perception that sustainable design and construction inherently contains a substantial cost premium is considered one of the main barriers to ESD [7]. Due to the fact that the construction industry and its clients generally tend to concentrate on short-term gains rather than long-term savings or investment opportunities, this perception that ESD buildings require higher initial construction costs and maintenance costs, is a major obstacle as this reduces the profitability of the project. Indeed, six Californian property developers interviewed in 2001 estimated that green buildings cost 10 to 15% more than conventional buildings [8]. In terms of capital development cost, there is a dearth of published information as regards the cost premium of ESD buildings. Information currently available tends to support the contention that ESD buildings require additional capital expenditure. Exactly how much extra depends upon the level of sustainability measures introduced, although there are some broad guidelines that can be deduced from the little available information.

The International Netherlands Group (ING) Bank in Amsterdam completed in 1987 is perhaps a pioneer in this field, with passive solar heating and ventilation, cogeneration and waste heat capture, day lit office space and interior cores, rainwater usage etc. The additional cost of these features is estimated at approximately 2% of the development cost [9]. The more recently completed 60L building in Melbourne, touted as “the premier green building in Australia” [10], is believed to have carried a capital cost premium in the order of 5%. An analysis of 33 projects certified as “green” by the United States Green Building Council (USGBC) found on average the capital cost premium is about 2%, although this premium varied from 0.66% level 1 certified buildings, up to 6.5% for level 4 (highest) certified buildings [11]. A further study conducted in the United States by Davis Langdon compared the cost of 45 USGBC certified green buildings with 93 conventional buildings. This study found that that there was no significant difference in the construction costs between the two categories of buildings [12]. This is not to say that ESD buildings will not cost more. The Colorado Court energy and resource efficient affordable housing project in California, estimated that the projects special energy measures cost in the order of 12% of the total construction cost [13]. The proposed Council House 2 building in Melbourne includes $11.3million of ESD features in a total building cost of $51.045 million, a premium of around 20% [14].

Yet there is a large body of evidence which suggests that ESD buildings, whilst having an initial capital investment surcharge, will repay this investment many time over in terms of lower energy and operational costs. The ING bank cost premium payback period was just three months and the annual savings of US $2.9M continue. The building uses a tenth of the energy of it predecessor, and a fifth of that of a conventional new office building in Amsterdam. [9] The Four Times Square development in New York was completed in 2000 and considered “the first skyscraper to embrace standards of energy efficiency, indoor air quality, and sustainable materials use..” is expected to have operational costs of 10-15% lower than a comparable project. The energy efficiency measures are estimated to have a payback period of three years [15]. A report to California’s sustainable Building Task Force, touted as “the most definitive cost benefit analysis of green building ever conducted” concluded that that minimal increase of capital investment of approximately 2% to support green technologies in buildings would, on average over a 20 year period, result in life cycle savings of 20% of total construction costs. Of these savings, approximately 30% (6% of total saving) emanated from reduced energy and resource usage, and 70% (14%) from increased production productivity and health values [11].

The issue of productivity and ESD buildings is an interesting one. Whilst the original thrust of ESD buildings focused predominantly around greenhouse gas emission reduction and associated energy cost savings, more recently the relationship between the internal building environment and production productivity has commanded attention. Clearly there are difficulties in relation to measuring the value of productivity as a function of building environment, due to the complexity of the many factors which contribute to the way human beings function. Whilst energy efficiencies can be measured fairly precisely, productivity of building inhabitants tends to be less certain [11]. Nevertheless, there is a strong band of case-study evidence to suggest that improved building environments support increased productivity.

The renovation of the Reno Post Office in Nevada, undertaken with objective of reducing energy costs, also heralded a 6% increase in worker productivity [16]. The Pennsylvania Power and Light Company incorporated task lighting for their drafting staff. The effect was to reduce energy bills by 73% which in itself produced a return on investment of 24%. But quicker drawing production times, coupled with increased quality and accuracy of work, reduced sick leave and improved worker morale, combined to produce a return on investment of over 1000%. [16]. After PNC Realty Services operated from a new "green" certified building in Pittsburgh, one of the Directors described the benefit of the new facility in terms of productivity and staff – "people want to work here, even to the point of seeking employment just to work in our building. Absenteeism has decreased, productivity has increased, recruitment is better and turnover less" [17]. Closer to home, the new administration building for Melbourne City Council is expected to save $1.12 million pa (approximately $120 per m2 pa) as a result of an increase in staff effectiveness estimated at 4.9% [14]. These benefits are considerable. Unpublished research conducted by Advanced Environmental Concepts found that the cost of sick leave remuneration in Australia in 2000 (excluding cost of replacement staff, disruption of production etc) was estimated to be $1550 per employee, whilst the cost of replacing employees, or staff churn, is estimated to be anywhere from 29 to 130 percent on an employee's annual salary.

But these benefits do not necessarily end with increased productivity and a happier workforce. The ING Bank credits its rise from No.4 to No.2 bank in the Netherlands with the new image the building has presented to the public [9] thereby giving rise to an opportunity to include psychic income. This is an element of return brought about by the benefits of owning and operating a socially desirable asset. This is similar to the benefit of owning a "trophy" property, a sentiment that is recognised by the market usually by the medium of a firmer capitalisation rate. It follows that the benefits of ESD should be recognized by the market and reflected in appraisal methodologies as the ESD culture becomes more widely adopted.

So the issue of productivity and performance in ESD buildings can include many dimensions including reduced staff absenteeism and turnover, increased production output and quality through employee comfort and enthusiasm, to improved organizational branding and public perception. Whilst these clearly have a financial benefit which, although perhaps difficult to measure precisely, is nevertheless very significant, it is becoming clearer that these benefits represent a watershed for ESD buildings. Suddenly a building becomes an organizational benefit, and the people within them are considered to matter, rather than simply a way of housing an organization [18]. ESD buildings are no longer just about reduced emissions or increased productivity, but the people who live and work within them are identified and acknowledged as a fundamental and worthy resource in their own right. And this has another financial benefit – reduced risk to occupiers of the building due to the adverse affects of poor indoor air quality. Clearly this has beneficial implications for the insurance of occupants within ESD buildings and the designers of such buildings. In one notable example, designers of ESD buildings who undertook appropriate training were offered a 10% insurance premium rebate as a reflection of the relationship between design and physical ailments, predominantly due to poor indoor air quality [19].

And thus ESD buildings take on a social dimension, in addition to the financial and environmental perspectives. Such an approach is in line with current trends toward "triple bottom line" reporting procedures. Indeed, such a model serves as apt business case decision making model, and a project deemed feasible under such criteria would no doubt embody the ethos of environmentally sustainable development.

3. Methodology

Residual valuation is adopted to illustrate the effect of considering ESD components of return to establish their worth. Owner-occupiers should see immediate benefits provided by this methodology in promoting their accommodation requirements to shareholders and the community. It is obviously less apparent to investors for the reasons outlined above and market recognition is required in these circumstances. Residual analysis is dependent upon a rearrangement of the developer's equation. The developer's equation may be more fully stated as follows:

Value = (Gross Income – Outgoings) / Capitalisation Rate

Costs = Land + Building + Finance + Marketing + Profit

The developer's equation is often rearranged in order to calculate land value. This is known as residual analysis or residual valuation as the case may be. It ties in with the concept that the return to land, economic rent, is a surplus return. In practice, economic rent cannot be separated from the worth of the land in unimproved terms. Thus the residual value is found as follows:

$$L= V-(B+F+M+P).$$

A hypothetical study using residual analysis is used to compare a conventional office property with an ESD property (see below).

Income occurs in many forms, the major classifications in the property context being:

- rental income e.g. rents for offices, retail space in shopping centres and industrial buildings
- sales income e.g. sales of residential lots or units (flats, apartments, detached homes), subdivided floors in office buildings or units on industrial estates.
- business income where the building is the business e.g. hotels in which income is derived from 'room-nights', food and beverage, dining and conference facilities and so on.

In the context of this paper, value may also be generated by increased productivity and the improved well-being of building occupants.

The establishment of net income for evaluation purposes is stressed. All costs of owning and operating buildings must be deducted to achieve net income and this should include allowances for repairs, preventive and corrective maintenance and programmed replacement of building components. Given that building occupants make accommodation decisions based on total accommodation costs (gross rentals), reduced outgoings should lead to increased net operating income.

The price of land is very much a function of market supply and demand. The residual study also allows for land purchase expenses as well as legal fees for conveyancing and for other associated fees and charges. Land holding costs are also included such as State Land Tax and municipal and water rates.

Feasibility studies are usually prepared in the first instance prior to any building documentation being prepared and it is at this stage that decisions are made about whether or not to pursue particular proposals. Accordingly building cost estimates must be "right" early on despite the lack of detail. All building costs must be allocated here including professional fees (usually around 8% to 12% of building cost).

Whether debt or equity, capital required for building development is all treated as a factor input accruing interest for the time that it is involved in the project. In the early stages of feasibility analysis, capital is considered in two tranches:

- Capital expended on the development from the outset, e.g., land costs and expenses. Interest is charged on the amount for the full development period.
- Capital expended during the development process, e.g., progress payments for building. Here, interest is charged on the amount for half the development period (assuming constant expenditure). Thus the whole of the required capital is not set aside at the commencement of the development process.

Sundry allowances, for either or both sales and leasing, often referred to as ripening costs, are also usually included in feasibility studies. Allowances for agents' commissions will be required (10% to 15% of the first years' rent for a leasing commission and 1% to 2% of the sale price for a sale commission) in addition the costs of advertising and promotion.

An allowance may also be made under this heading for the letting up process. It is rare that a building is fully precommitted so that the full rental is paid from the date of completion. Usually an allowance is made for vacancies or the business starting up process. Any leasing inducement required could also be accounted for here.

The profit motive is of course the main driver to building project development. Profit constitutes the developers allowance for risk and return and it is treated as a development costs in residual analysis. Feasibility studies are often computed in order to establish potential profitability.

4. Data

A comparative study of two hypothetical properties, one a conventional office building and the other having ESD features, is provided to illustrate the point of this paper. It is accepted in this paper that the ESD building provides an improved internal environment leading to the benefits reviewed above. The data used in the study are described below.

Market rental values for office buildings are currently around $300 per m2 gross effective after allowing for lease incentives. Property economists currently predict a substantial rise in rents (50% or more) over the next year or two [20]. This will be brought about by the removal of the lease incentives to achieve the levels of current face rentals. A gross rental value of $400 per m2 has been adopted for the conventional building in this study. A 5% rental premium is allocated for the ESD building to reflect the improved internal environment.

An allowance is also made for improved productivity. Referring to the CH2 building in Melbourne, salary savings of $1.12 million pa are estimated and this amounts to $120 per m2. A saving of $100 per m2 is allowed for the hypothetical ESD building in this study.

The outgoings for the ESD building have been reduced from $80 per m2 to $70 per m2 in line with the findings discussed above.

The net operating income is capitalized at 8% for the conventional building. An indicative allowance for psychic income is made by firming the capitalisation rate to 7.75%. It is assumed that both buildings are fully precommitted.

The building costs are estimated at $30 million for the conventional building and $35 million for the ESD building to allow for the additional costs of ESD features as outlined above. The same development period is used for both buildings.

An interest rate of 8% is adopted for both buildings.

Developer's profit is included at 10% for the conventional building and 15% for the ESD building. This reflects an additional risk for the latter despite the improved returns listed above.

5. Results and Conclusions

The residual studies are illustrated in table 1. As can be seen, the land value for the conventional building is $2.2 million and that for the ESD building is $8.8 million. This hypothetical study indicates that the worth of the ESD building ($58 million) is substantially greater than its estimate of price ($40 million) as suggested by the conventional building.

The study shows that in the current market where ESD buildings are valued as though they are conventional buildings, the application of the concept of worth demonstrates that ESD buildings can generate higher values/benefits. As stated above, this concept can be readily accepted by owner-occupiers, but acceptance in the investment market requires further research and analysis including:

- Psychic income
- Improved rental values
- Better technical performance of ESD buildings
- Improvements in productivity and other building occupant advantages.

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Table 1: Residual Analysis (on following page)

DEVELOPMENT RETURNS			**Conventional Building**			**Environmental Building**		
		Floor area	Rent/sqm	Net Rental		Rent/sqm	Net Rental	
Gross rental value			$400			$420		
Staff savings			$0			$100		
			$400			$520		
Outgoings			$80			$70		
Net rental value		10,000	$320	$3,200,000		$450	$4,500,000	
Net Income					$3,200,000			$4,500,000
Capitalisation Rate					8.00%			7.75%
					$40,000,000			$58,064,516
Less sales commissions and costs			1.50%		$600,000	1.50%		$870,968
					$39,400,000			$57,193,548
Less letting commissions and costs			15.00%		$480,000	15.00%		$675,000
NET RETURNS					$38,920,000			$56,518,548
DEVELOPMENT COSTS								
Developer's Allowance for Profit and Risk				10.00%	$3,538,182		15.00%	$7,371,985
					$35,381,818			$49,146,564
Building costs				$30,000,000			$35,000,000	
Construction Finance	interest		8.00%			8.00%		
	construction period		24		$2,400,000	24		$2,800,000
GROSS RESIDUAL LAND VALUE					$32,981,818			$46,346,564
Less rates and taxes					$100,000			$100,000
					$32,881,818			$46,246,564
Less holding costs	interest		8.00%			8.00%		
	preconstruction period		6			6		
					$5,480,303			$7,707,761
					$27,401,515			$38,538,803
Less land purchase expenses			6.00%		$1,551,029	6.00%		$2,181,442
NET RESIDUAL LAND VALUE					$25,850,486			$36,357,361

Parameters of accessibility for sustainable design

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Abstract

Sustainability in the built environment includes taking the basic questions of accessibility into account in the pre-planning stages. Accessibility in the built environment includes physical access, visual access and audio access. Well-planned, accessible buildings and urban environments require less retrofitting and modifications during the building life cycle, and are therefor more sustainable. Institutions that produce planning guidelines are essential tools for planning the built environment.

Keywords: sustainability, physical access, accessibility, design, programming

1. Overview

1.1 Background

In 1992 the United Nations assembled the UN Conference on Environment and Development in Rio de Janeiro, which was based on the Brundtland report (WCED World Commission on Environment and Development 1987. It adopted a number of documents, in particular the Rio Declaration and Agenda 21, the Climate and the Biodiversity Conventions (United Nations 1993) pointing out pathways towards sustainable development. This includes how to reconcile social development and environmental protection in a vibrant but resource-efficient economy. In 1995, the Commission on sustainable development CSD has included the institutional dimension of sustainability to the environmental, economic and social ones, resulting in a four-dimensional concept of sustainability.

The concept used is based upon a balanced approach, aiming to avoid irreversible damage in either dimension with equal emphasis. This is equivalent to not overburdening the carrying capacities of the subsystems underlying the different dimensions. Irreversible damage or exploitation must not take place concerning humans (i.e. secure health and self-realisation), the environment (i.e. safeguard viability), the economy (i.e. guaranty competitiveness and satisfaction of material needs) and the institutional system (i.e. make it reliable, trustworthy but open to evolve). The WSSD (World Summit for Sustainable Development in Johannesburg, 2000) further adopted policies for Participatory openness to major groups, gender and minority equality and the decentralisation of power as prominent examples from Agenda 21. [1]

The UN Decade of Education for Sustainable Development (DESD) was launched at UN Headquarters on 1st March 2005. The UN Secretary-General Kofi Annan noted that, in addition to the international launch, a series of regional and national launches of the Decade will take place during the course of 2005. See http://www.un-ngls.org/decade-education.htm for details.

1.2 Accessibility

Accessibility in the built environment includes physical access such as ramps and elevators, visual access such as comprehensible colours and shapes, and hearing access, such inductive amplifiers for meeting rooms and auditoriums.

When such requirements are understood in the programming stage of building projects, then their actualization through the bidding process into realization is clear. Building Information sheet requirements and standards exist, but their application in a later phase is virtually impossible, without forfeiting architectural quality or needless, costly changes in the working drawing stage. Enlightened owners and developers understand the attractivity of buildings that are accessible to all possible users. The concept of seniors living at home for as long as possible also supportws the idea of accessible housing on the general market.

1.3 Objectives

What steps must the designer take to ensure that a building project contains all necessary parameters for accessibility in the conceptual phase? The requirements of accessibility that are observed at the implementation stage are time consuming and costly. Awareness of standards, guidelines at the municipal, national and European level are absolutely necessary to serve the client with building solutions that have a long life cycle and low retrofit need.

2. Requirements

Existing standards for physical, visual and audial accessibility exist at the local, national (Finnish) levels and the EU level. The Finnish Building regulations RakMK section F1 barrier-free building, and the Dwelling design regulations G1 require that all persons are allowed access to all public, service and business buildings and sites. The RT Standard sheet Accessible mobility and environment RT 09-10692, Nov 2002 and (new version 2005) covers the requirements for access routes, parking spaces, ramps, stairs, lifts, entrances, doors, toilets, saunas, meeting rooms, hotels and dwelling spaces. [2]

EU building standards for accessibility are given as recommendations, such as The European Design for All **e-Accessibility** Network (EDeAN), established in July 2002, in accordance with one of the specific goals of the **eEurope 2002 Action Plan.** The Action Plan was agreed on and committed to by the European Commission and all the member states**.** One of the action points included in the plan was to "ensure the establishment and networking of national centers of excellence in design-for-all and create recommendations for a European curriculum for designers and engineers".

EDeAN was primarily created to provideinput for European Curricula in Design for All, a forum for Design for All issues, idea sharing through joint activities such as conferences, symposia and exchanges of students and scholars. EDeAN is also charged with fostering awareness and promoting changes of culture in the public and private sectors. It will also establish links with appropriate education channels to embed Design for All best practices in new curricula. Through a series of common activities and proposals, it is hoped that the network will become a cohesive group that can effectively work toward the advancement and excellence of Design for All.

The eEurope action Plan section 2c. states "Participation for all in the knowledge-based economy states that as the knowledge-based economy advances, the exclusion from ICT becomes more and more a barrier to economic, employment and social opportunities and to using public services. Disadvantaged areas and groups are at higher risk of lagging for various reasons including low-income and poverty, lack of ICT infrastructures, awareness and training opportunities, or difficulties of access because of disabilities. On the other hand, ICT can overcome barriers of distance, distribute more equally knowledge resources and generate new services for citizens with special needs. . . Thus, the risks of the digital divide need to be transformed to digital opportunities by actions focussed at disadvantaged groups and areas. Accessibility to ICT and on-line information and services, taking particularly into account the needs of people with disabilities, is a precondition for ensuring an Information Society open to all. In this respect, governments have to take a lead to ensure equal opportunities of access". [3]

3. Accessible projects

Two Projects which have observed the standards of accessibility in the pre-planning stages are Helsinki Polytechnic Art and Media building TAVI and the IIRIS center for the Visually impaired.

The Helsinki Polytechnic Art and Media building TAVI extension at Hämeentie 161 in Helsinki is a 1625 m2 three-storey extension to an existing building. The students are very creative, and can often be found on evenings and weekends studying. Both the owner and the architect understood the parameters of accessibility, which made the design process from schematics to working drawings without major changes for accessibility reasons. However, the building review board required that the floor levels of the building be lower than the existing ones, to avoid excess height. This caused the need for ramps, but were made at the maximum slope of 1:12.5. The building has an accessible lift and WC.

The Finnish Federation of the Visually Impaired (FFVI) service center IIRIS is a special service provider with a social element as well as an advocacy organization for the blind and the partially sighted. The aim of the Federation is to secure the blind and visually impaired an equal status with other Finnish citizens. To achieve this the Federation seeks to improve the capabilities and skills of the visually impaired, while also trying to influence the society at large. Particular attention for problems of glare, lack of contrast and orientation have been adapted into the building design. Other physical accessibility questions such as ramps, accessible toilets, and services for the blind are also an integral part of the building. [4]

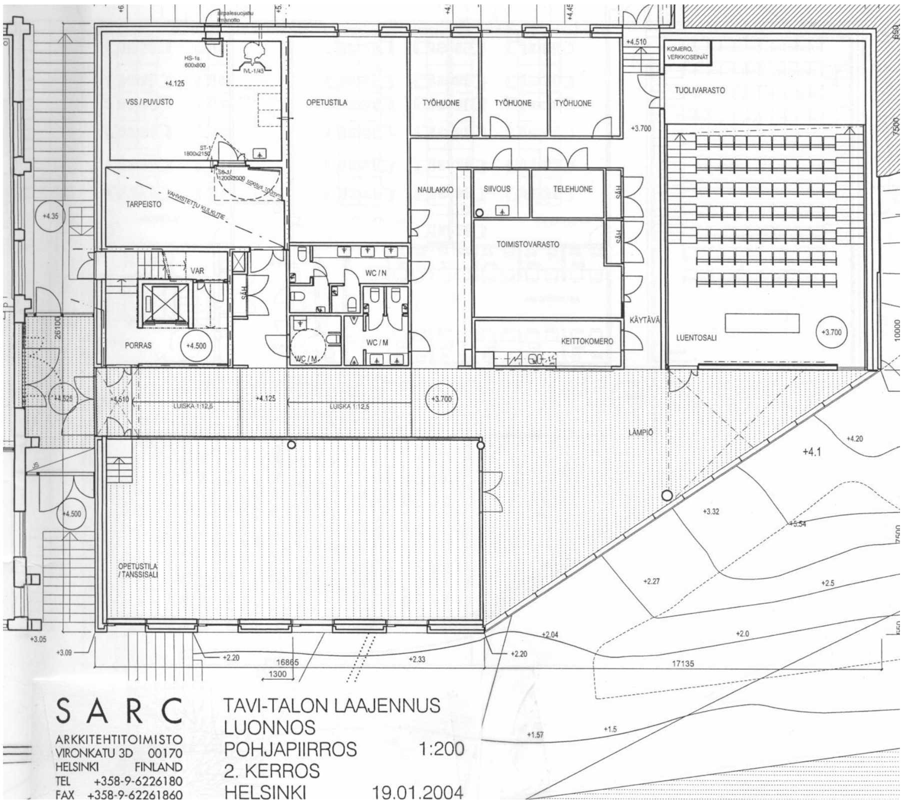

Figure 1: Floor plan of the Art and Media extension, Helsinki Polytechnic

Figure 2: Finnish Federation of the Visually Impaired, Iiris building

4. Results

In the two projects shown, the owners strategy and the designers professional ability to understand the needs of physical and digital (internet) accessibility were incorporated into the design project brief. Space requirements, budgets and services were designed with accessibility in mind as part of the design process, not as an extra permit phase hindrance. The finished buildings will have a longer life cycle with less costly retrofitting, because the design process included all needs of present and future users.

5. Conclusions

Owners and designers that understand both the law and the reality of accessibility in the workplace, schools and dwellings can include accessibility into their projects in the schematic phase, rather than repair buildings later for special users. Designers can refer to the accessibility parameters given, and refer to standards and recommendations to check their projects for their level of accessibility.

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Life-Cycle Values

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Abstract

Life-cycle values are mainly caused by combination of location and most significant characteristics of the facility. Life-cycle economical, energy-saving, ecoefficient, healthy and social facilities are quite similar: durable enough and desirable with functional, change-flexible and unrestricted spaces as well as reliable, advantageous and undamaged systems and other products and materials.

Life-cycle value analysis will be utilized by different kind of organisations in building and facility trades when comparing concurrent technical solutions with each other and making cost-effectiviness, profit and cash flow analysises. The life-cycle economical comparisons should be focused on those characteristics and products with real importance.

Advicing shall be organized through many kind of channels and training programmes.

Keywords: Life-cycle cost, life-cycle economy, values

1. Introduction

The Life-Cycle Value model presented is based on results in networking projects (Table 1) most important of which LCC for building trade (www.LCC-bygg.com) and LIFETIME (www.ril.fi/Resource.phx/tietop/lifetime.htx) as well as working in ISO (15686-5) and CEN (TC348) - standardisation expert groups and developing so many kind of LC-tools.

Life-cycle valueing will be utilized by different kind of organisations in building and facility trades when comparing concurrent technical solutions with each other and making cost-effectiviness, profit and cash flow analysises.

Table 1: Networking (references)

Network	State	Web-adress	Contactperson in Finland	Goals
ISO 15686-5	**Has been approved as DIS**	www.iso.org/iso	Sakari.Pulakka@vtt.fi & Pekka.Vuorinen@rakennusteollisuus.fi	**Has as expert-work developed a standard draft called Whole Life Costing**
LCC for building trade	**Finished 12/2004**	**www. lcc-bygg.com**	Sakari.Pulakka@vtt.fi	**Has developed a Nordic LCC –model included also in ISO15686-5**
REM	**Finished 3/2005**	**www. rakennusteollisuusrt.fi**	Arto.Suikka@rakennusteollisuus.fi	**Has collected LC-based criterias for build up and building design**
LifePlan	**Finished 6/2004**	**www.pim.vtt.fi/ lifeplan/view**	Tarja.Hakkinen@VTT.fi	**Has collected LC-information of building products**
EcoCost	**Ongoing**	**www.ymparisto.fi/default.asp?contentid=64193&lan=FI**	Sakari.Pulakka@VTT.fi	**Developes a LC-model and a collection of eco-efficient solutions**
Lifetime	**Ongoing**	**www.ril.fi/ Resource.phx/tietop/lifetime.htx**	Asko.Sarja@VTT.fi	**Has collected global information about LC-based methods and tools**
LIFECON	**Finished 4/2004**	**www.vtt.fi/rte/strat/projects/lifecon/**	Asko.Sarja@VTT.fi	**Has developed LC-based tools for planning**
EURO-LIFEFORM	**Finished 12/2004**	**www.eurolifeform.com**	Olavi.Tupamaki@villareal.fi	**Aims to develop methods for Life-Cycle Economy**
Life-cycle models of construction	**Ongoing**	**www. rakennusteollisuusrt.fi**	Ilkka.Romo@rakennusteollisuus.fi	**Aims to show LC based methods for construction production and contracting.**
CUBENET - Energy Services	**In prepatation**	**www.akseli.tekes.fi/ Resource.phx/rapu/ talotekniikka/cubenet**	Pekka.Tuomaala@VTT.fi	**Aims to increase companyactivities concerning energy saving solutions**
SUNTOOL	**Ongoing**	**www.managenergy.net/download/nr134.pdf**	Jyri.Nieminen@vtt.fi	**Developes life-cycle economical and ecoefficient solutions to small house areas**
SARA –Value-networked construction	**Ongoing**	www.akseli.tekes.fi	Mika.Lautanala@tekes.fi	**Aims to develop information-technology based planning and evaluative methods.**
OPET-Building	**Ongoing**	**www. motivaenterprises.com**	Ilari.Aho@motiva.fi	**Network of LCC -experts for builders**
Rembrand – facility management	**Finished 9/2004**	www.akseli.tekes.fi	Juhani.Reen@rakli.fi	**Has produced methods and tools for facility management**
PeBBu-thematic network	**Ongoing**	www.pebbu.nl	christer.Finne@rts.fi	**Aims for the inter-national implementation of the principles of Performance Based Building**

2. Objects of Life-Cycle Valueing

Life-Cycle Valueing is a tool for value-managing of facility-based human terms, quality, culture and economy (Figure 1).

The figure 2 outline examples of objects for life-cycle based decision making within the area of facility maintenance. The life-cycle economical comparisons should be focused on those characteristics and products with real importance.

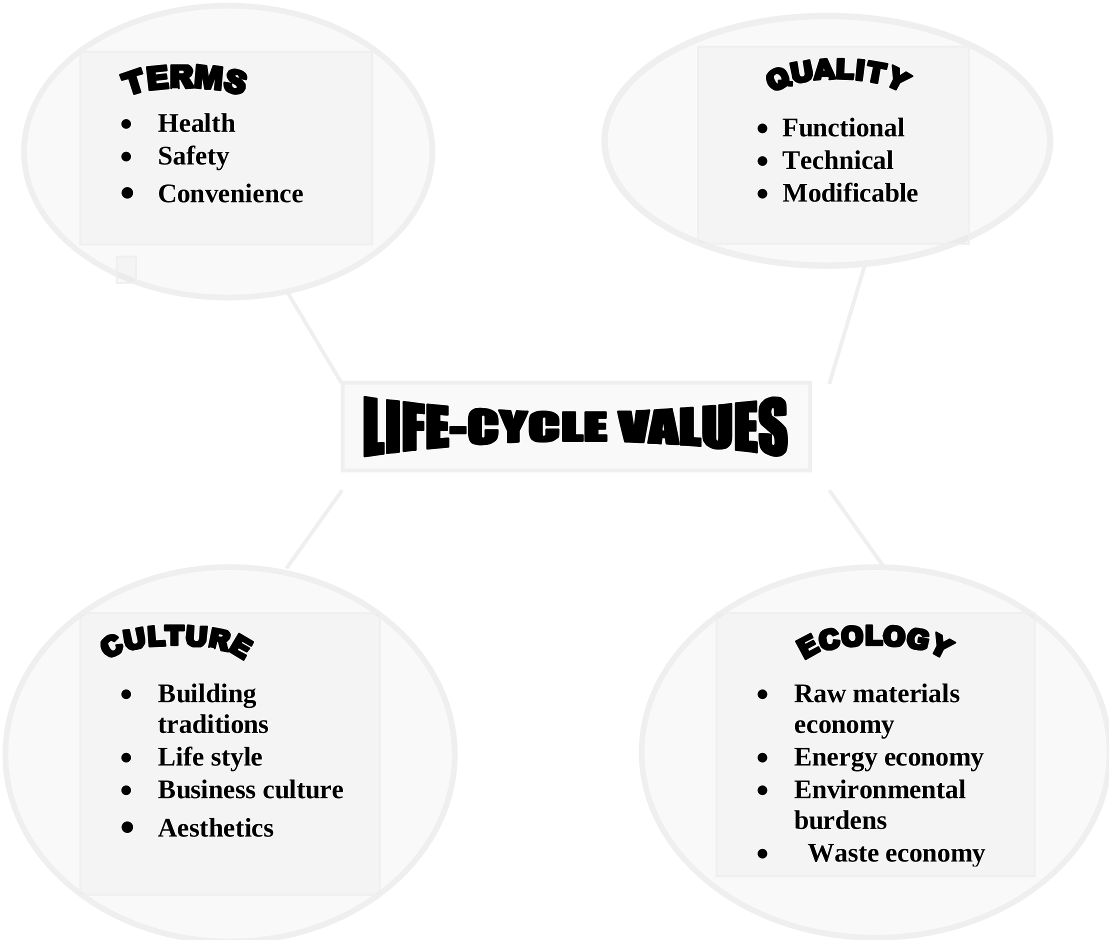

Figure 1: Value factors

In *facility investment* and space acquisition the main interest is concentrated on location, use of spaces and the most essential characteristics (Figure 3). The calculations will also be utilized by comparing possible life-cycle tenders.

Product selection shall be concentrated with facades and windows, base floors and roofs, separation walls, coatings, furniture, ventilation, heating and electrical systems and routings as well as information systems.

By *use and maintenance* the important life-cycle areas are planning, use directions of ventilation and information technology and applying right maintenance methods.

Facility development shall be based on *condition determination*, suitable new construction practises and definition of wanted functionality. The solutions are mainly based on original state of the building: appearance, space complexes, level of energy consumption, modification rate and other technical settings. The life-cycle advantageousness shall be compared with corresponding new house.

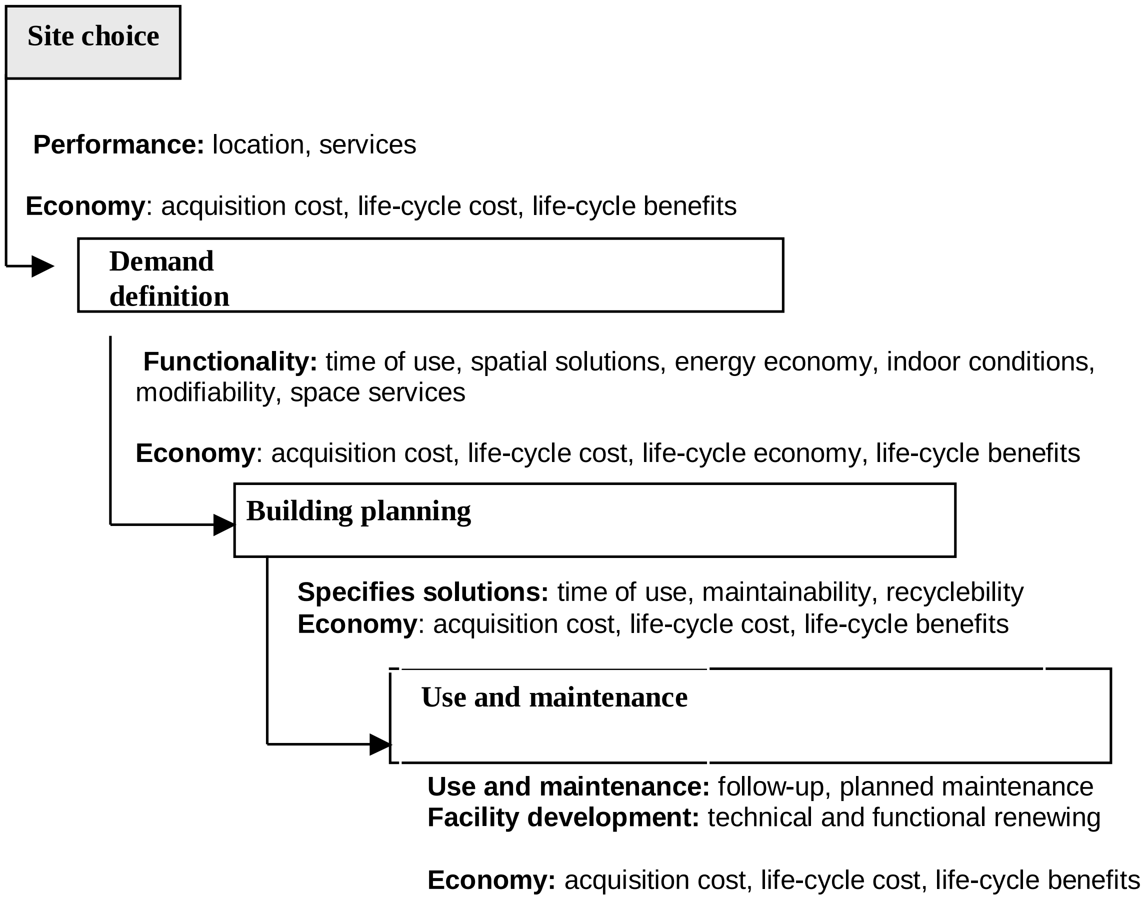

Figure 2: Focusing of life-cycle based decision making

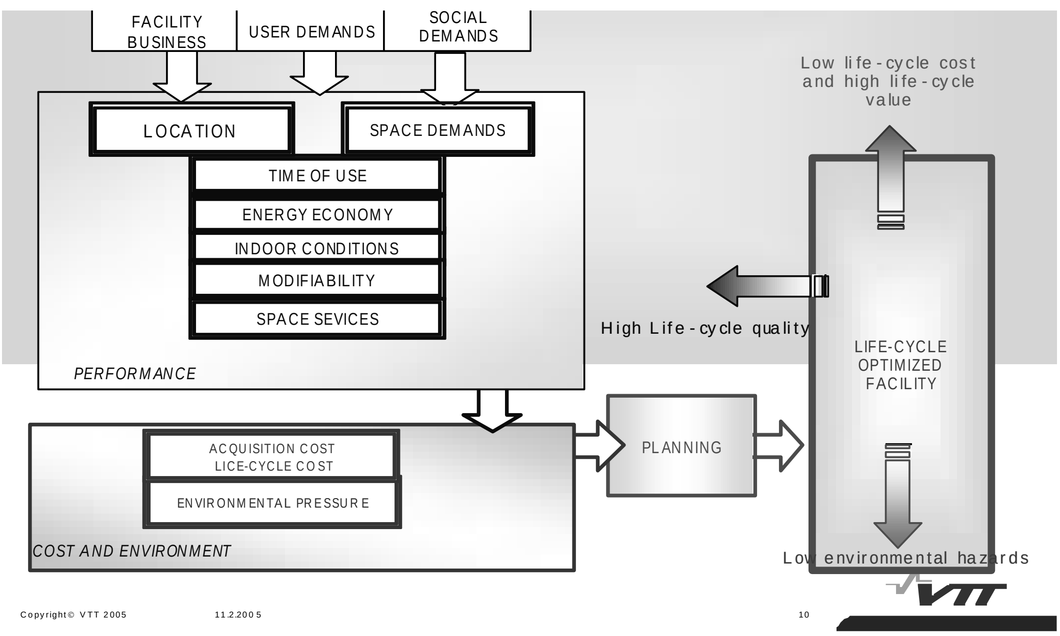

Figure 3: Methods of Life-Cycle Valueing

3. Methods of Life-Cycle Valueing

The LC- method is primary based on CEN/TC 348 (Facility Management) and ISO15686-5 (Whole Life Costing), other manysided international co'operation as well as numerous national development, networking and tooling activities. It includes following definitions:

- **Life-Cycle Costs** (total cost over a technical, economic or functional life-cycle) or Whole-Life Costs (total cost over the whole life of facility, building or component) are usually caused by acquisition, operation, maintenance, modification, renewals and environmental needs for building, system or product (Table 2) as well as possible disposal. The same classification may be applied also in case of facility development as well as individual acquisitions. Present value calculation (all costs accuring within a chosen period of time discounted to a current cost level using a relevant discount rate) is the primary method for life-cycle costing. And, annual costing is fair for cash flowing.

Table 2: Classification of life-cycle cost

Type of life-cycle cost	Description
Acquisition cost	Investment including all material, labour and sub costs caused by acquisition of facility, product or material. If the length of life cycle is lower than lifetime, the acquisition cost include only the repayd share.
Funding cost	Price of money within chosen life-cycle.
Facility management	Salaries, rents, taxes, insurances.
Operating cost	Continual cost caused by the use of building including energy, water, waste, cleaning, other space services etc.
Maintenance cost	Time-planned maintenance and renewing of components.
Modification cost	Cost of spatial modifications.
Development cost	Improvement of technical systems, building parts and/or environment through demand management and building condition charting.
Risk cost	Unexpected cost caused by moisture, fire, storms, breakings of systems etc.
Environmental costs.	Possible needs for soil refreshment and sheltering, use of raw material, cost of demolition and recycling etc.

- **The length of life-cycle** is typically 10 or 25 years. Functional life-cycle may be short, many social analysises mean very long life-cycles. The choice of life-cycle will be based on real needs of decision making: Budgeting time, Loan time, Permanence of actions, Period of facility development, Time for life-cycle planning,…. The life-cycle has a remarkable influence on cost distribution (Figure 4).

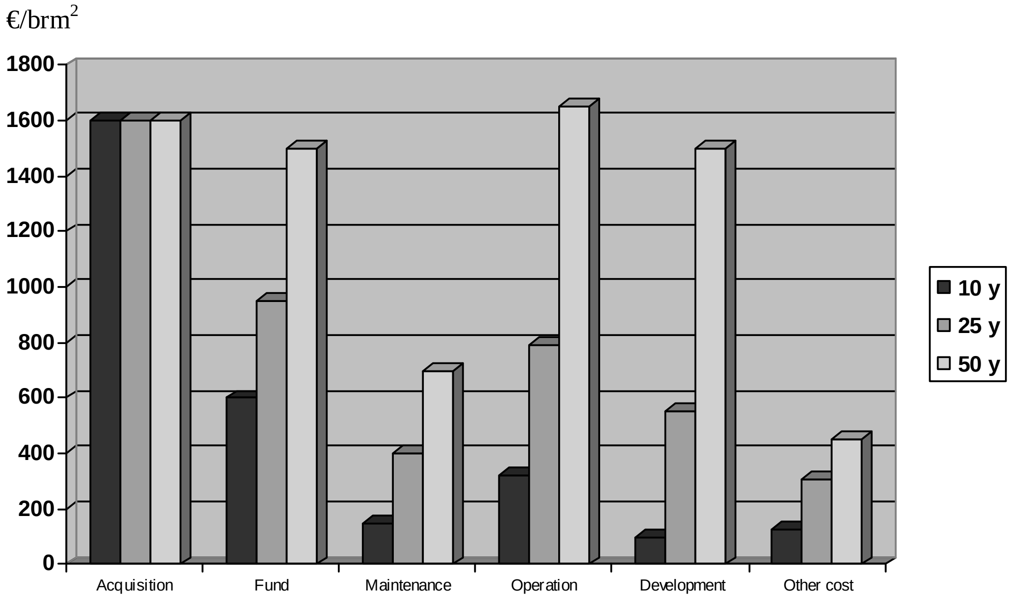

Figure 4: Division of life-cycle costs in different life-cycles

- **Real rate** (nominal rate – inflation) is based on real need and price of money**.**
- **Life-Cycle Economics (LCE)** may be calculated as difference between Life-Cycle Income (LCI) and Life-Cycle Cost or directly as difference in life-cycle costs

$$\mathbf{LCE = LCI - LCC} \text{ tai } \mathbf{LCE = LCC_{diff}}$$

- **If the Resale Value (RV)** is taken in account (for example based on differences in functionality characteristics, remaining life time and possible space service value), **Life-Cycle Profit (LCP)** is the sum of life-cycle economics and difference in resale value:

$$\mathbf{LCP = LCE + RV_{diff}}$$

- By means of profit calculation may be defined **Profit rate** and **Payback time**.
- **Life-Cycle Benefit** is the best relation between performance characteristics, acquisition and life cycle cost, possible life cycle incomes and effects on resale and Environmental Hazards (EH). It may be calculated by means of equation

$$\mathbf{(LCI_i \times RV_i)/(Aq_i \times LCC_i \times EH_i)}$$

- The **sensitivity analysis** may be based on: optimistic ***–probable–*** pessimistic

Possible economical **risks** on different levels

- Advancement of resale value, permanence of characteristics, maintainability and chances of valuation and combatibility of systems with further needs for facility management.
- Mistakes concerning building planning, accessibility of building products, operative experiences, damage riskability and way of use.
- In production process insufficiency of professionals, problems with acquisitions, actions and transfer of project start towards winter time.
- In use and maintainance underprizing in planning phase, defaults of use and maintenance directions, unexpected rises of prises, larger and careles use of systems, unexpected damages and problems with usability in case of user changes and faults and lacks of maintenance actions.
- In case of facility management a failed consolidation of actions, unexpected damages revealed by demolition and disturbances caused to users.

Life-cycle values are mainly a consequence of the combination of location and most significant performance characteristics of the facility (Table 3).

Table 3: The effects of alternative life-cycle characteristics to the costs compared with ordinary parameters (examples)

Location Southern Finland Life cycle 25 y Real rate 2 % Cost level 6/2005	Acquisition cost **€/m²**	Life-Cycle Cost **€/m²**
Choice of life-cycle characteristics		
*Heating energy economy		
- low-energy level	+20	-30
- minimum energy level	+50	-20
* Inner climate		
- quality class S3	-50	-75
- quality class S1	+80	-120
* Modification rate		
- spacially modifical	+90	-25
- very modificable	+150	+10
* Levels of inner quality		
- high class	+150	+250
- representational	+500	+750
Choise of products		
* Facades		
- highclass facades	+100	+ 130
* Windows		
- energy saving windows	+15	-20
* Effectiviness of heat recovery		
- effectivity 40 %	+5	-8

As an **application example** of life-cycle optimization (acquisition cost, price of money, life-cycle cost, life-cycle economy, profit rate) has been compared a typical office building to a house with better functionality (Table 4). That has been reached by means of life-cycle optimized technical solutions including effects on user activities. For example better inner climate and lower energy consumption is based on interactive ventilation system with excellent automatic control engineering, good insulation ofbase floor, walls, roof and windows as well as effective heatrecovery of ventilation. The inner temperatures are adjusted to stay stable. And longer time of use is based on sufficient structural durability, higher rate of modifications and low riskability of any kind of damages.

As *economical parameters* are calculated

- real and relative effects on acquisition cost and life-cycle cost
- relation to the multiplication of acquisition cost, environmental hazards and life-cycle cost

As conclusions may be generalized that a life-cycle optimized office building compared with a traditional office building

- is 10...40 % more expensive as acquisition
- means 0...20 % higher life-cycle cost
- makes it possible to have 10…30 % higher life-cycle incomes
- has 15...50 % higher resale value
- is very advantageous as investment
- is very cost-effective when observing also environmental hazards
- means as copied remarkable benefits to society

More over it has been noticed that the officeworkers have less symptons and a little better productivity because of better inner climate, high level of information technology, maynsided space services and better work satisfaction.

As an ordinary building falls into decay and goes out of date, a life-cycle optimized building ages worthly and and intelligently.

Table 4: Example of calculating life-cycle economy of life-cycle optimized office building compared with an ordinary

		Traditional building	Life-cycle optimized building
Location	Southern Finland (Vantaa)		
Building type	Office building with steel frame		
Area	2 000 brm²		
Life cycle	20 y		
Realrate	5 %		
Portion to be financed	70 %		
Cost level	6/2005		
FUNCTIONALITY			
Time of use		50 years	80 years
Modification		modular	free
Relational energy consumption		100 %	75 %
Inner climate		ordinary	excellent
Space services		ordinary	manysided
RELATIONAL ENVIRONMENTAL EFFECTS			
Emissions CO_2 eq.		0,60	0,45
Unrenewable energy resources		0,20	0,15
Wastes		0,10	0,07
Other use of natural resources		0,05	0,04
Environmental risks		0,05	0,03
Environmental **H**azard index (**EH$_i$**)		**1,00**	**0,74**
ECONOMICAL EFFECTS		€/a/m^2	€/a/m^2
Acquisition cost **Aq**		**85**	**110**
Funding cost		36	46
Facility administration cost		5	7
Maintenance cost		14	12
Operating cost			
Heating energy		5	3
Electrical energy		10	12
Other operation cost		8	10
Modification cost		25	3
Environment cots		3	2
Lif**e**-**C**ycle **C**ost	**LCC**	**191**	**205**
Life-**C**ycle **I**ncomes	**LCI**	208	240
Life-**C**ycle **E**conomy	**LCE = LCC$_{dif}$**	**+17**	**+35**
RELATIONAL DIFFERENCES			
Acquisition cost index	Aq_i	1,00	1,29
Life-Cycle Cost index	LCC_i	1,00	1,08
Life-Cycle Income index	LCI_i	1,00	1,16
Resale Value index	RV_i	1,00	1,45
Life-Cycle Benefits	**$(LCI_i \times RV_i)/(Aq_i \times LCC_i \times EH_i)$**	1,00	**1,63**

4. Conclusions and suggestions

There are different needs for life-cycle based decision-making on different levels of activities to be utilized in different kind of organisations. LC-systematics should be based on ISO15686-5 and CEN/TC 348 when applicable.

As the starting point of generalizing life-cycle based decision making is to specify concepts and calculation model as far as focusing the most essential life-cycle characteristics on different levels of facility business. They also cover the most important objects of technology development. Generalizing of life-cycle contracts shall happen at the same time both in producing companies and in client organisations.

Town planning and realistic population forecasting have the most remarkable importance on time of use of building stock. Also compact and complimental society structures are the way to save several thousand euros per habitant during 30...50 years. So areal life-cycle optimization is necessary next to individual building planning. For example the transfer towards ecoeffective society takes at least 25 years. Generalizing of life-cycle optimized facility concepts should mean

- Reduction of heating and electricity energy making it easier to optimize energy management and increase importance of renewable energy resources.
- Increase of both GNP and employment and transferring labour inputs from energyproducing countries to homelabd and from wasting to recycling services.
- New kind of business possibilities (for example building concepts, coating structures, recycling products).

Life-cycle economical, energy economical, ecoefficient, healthy and social facilities are quite similar: durable, energy-saving and desirable with functional, change-flexible and unrestricted spaces and reliable, advantageous, undamaged recyclable systems, other products and materials. There shall be combined the most economic and ecoefficient performance characteristics to the life-cycle optimized technical solutions in the bestpractise (or nextpractise) building concepts.

The public sector has a central role in promoting life cycle advantageous solutions through its own production and giving directions and building codes. This requires commonly approved technology foresight systematics. The private sectors are applying directions and codes in life-cycle optimized ways and seeking new areas of business which aim at high profits through intensive innovation processes. This means growing international value networking.

Advicing towards life-cycle valuable solutions shall advanced through multisided channels and training programmes. The role of innovation technology is also increasing:

- Product information databases (for example LifePlan)
- Web –based costing tools (for example BeCost)

- Product modelling (for example RYHTI –HVAC –Costing tool)
- Mapinfo based space-costing (for example TILASUKU –tool)
- Simulation tools (for example VTTHouse -tool)
- Client-Demand management (for example EcoProp -tool)

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A review of sustainability in construction and its dimensions

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Abstract

Sustainability is becoming an increasingly important topic for construction research. It is a multi-dimensional topic involving social, economic, and environmental aspects. Sustainable construction generally refers to the application of the principles of sustainable development in the construction industry. Its definitions, interpretations and priorities will be largely dependent on the context of study. Despite the many claims to benefits that sustainable construction can bring, sustainability still seems not mainstreamed in the construction industry. Focusing on context of the UK construction industry, this paper provides an overview on the subject of sustainable construction and introduces some key knowledge gaps around the issues of conceptualisation, linkages to project life cycle, linkages to project management, implementation mechanisms and tools, and construction procurement. It is hoped that if the gaps are filled, there might be a better chance for sustainability to gain its due place in construction. Through a synthesis of the relevant literature, the paper reviews the criteria representing the social, the economic and the environmental dimensions of sustainable construction. Further research suggests the use of the Delphi Technique as a means of developing a common understanding and consensus among experts regarding sustainability criteria that public clients should address in developing a procurement strategy.

Keywords: sustainable construction, review, social, economic, environmental

1. Introduction

Sustainable development has gained an increasing importance in the construction industry. The application of its principles in this industry is generally described as sustainable construction. With the increasing recognition of the importance of the concept, huge number of definitions have emerged. One of the most common definitions of sustainable development is the one introduced by The World Commission on Environment and Development [1] "*Humanity has the ability to make development sustainable – to ensure that it meets the needs of the present* *without compromising the ability of future generations to meet their own needs"*. Focusing on the UK context, this paper provides an overview on the subject of sustainable construction, explores some of the knowledge gaps related to the subject, and presents the criteria underpinning the social, the economic and the environmental dimensions of sustainable construction. Further research is suggested to obtain a consensus regarding sustainability criteria that should be addressed by public clients in developing procurement strategy.

2. Sustainable construction – an overview

In general, sustainable construction is about the application of sustainable development in the construction industry. Raynsford provides a detailed definition for sustainable construction [2] *"Sustainable construction is the set of processes by which a profitable and competitive industry delivers built assets (buildings, structures, supporting infrastructure and their immediate surroundings) which*

§ *enhance quality of life and offer customer satisfaction*

§ *offer flexibility and the potential to cater for user changes in the future*

§ *provide and support desirable natural and social environments*

§ *maximize the efficient use of resources."*

The definition offered by Raynsford puts emphasis on both the process and the product and introduces some aspects of social, economic and environmental sustainability. However, the definition does not fully capture all the aspects implied by the term. A more comprehensive definition is offered by Constructing Excellence [3] which introduces sustainable construction as the application of sustainable development in the construction industry and suggests that sustainable development is *"all about ensuring a better quality of life for everyone, now and for generations to come, through:*

§ *social progress which recognises the needs of everyone*

§ *maintenance of high and stable levels of economic growth and employment, whilst*

§ *protecting, and if possible enhancing, the environment, and*

§ *using natural resources prudently*

Sustainable development embraces the three broad themes of environmental, social and economic accountability, often known as the 'triple bottom line'." [3]

Regardless of the context, sustainable construction always integrates different dimensions, including social, economic and environmental dimensions. However, the interpretation and the priorities of sustainable construction could be largely dependent on the context as the needs and the conditions of the developed countries are widely different from those of the developing world [4]. For example, the principles highlighted by Gibberd [5] have been developed to support sustainable construction in developing countries and in particular South Africa. Another example could be found in the comment offered by Ofori [6] on the paper of Hill and Bowen [7]. Ofori argued that the paper of Hill and Bowen was written to reflect, at large, the point of view of developed countries in spite of mentioning some issues that were relevant to the context of South Africa. Realizing the differences between developed and developing countries, CIB and other organizations published "Agenda 21 for Sustainable Construction in Developing Countries" [8]. According to this Agenda, such differences are related to the problems and their scale, development priorities, capacity of local industry and government, skill levels in addition to cultural and world view issues which influence the understanding and implementation of sustainable development and construction.

However, it seems that there is a lack of awareness about sustainable construction in both the developed and the developing worlds. In the Netherlands, for example, a survey which was carried out in 1998 showed that quarter of architects and half of the building contractors did not know what sustainable construction was [9]. In the US, Landman showed that lack of training and education in sustainable design/construction was one of the primary barriers to more widespread sustainable building practices [10]. Watuka and Aligula, in their study of sustainable construction practices in the Kenyan construction industry, reported that sixty four percent of the respondents on a questionnaire administered to Architects, Engineers, Quantity Surveyors and Contractors indicated lack of awareness about sustainable construction practices [11].

In the context of the UK, promoting awareness and understanding of sustainable construction was declared as one of the objectives of the UK strategy for more sustainable construction [12]. Although awareness within the construction professions and trades was increasing, it was not enough [13]. The need to raise awareness of sustainable development throughout the industry was also highlighted by the publication "Society, Sustainability and Civil Engineering" [14]. Lack of awareness might be attributed to lack of clear conceptualisation of sustainability, lack of clear case for sustainability benefits, lack of integration of sustainability issues in education and training programmes, the traditional perception that limits the understanding of sustainability within the environmental dimension, the dominance of economic drivers in the performance of businesses at the expense of social and economic issues, and lack of long term perspective.

But lack of awareness is not the only barrier to achieving sustainability, which still seems far from reach in an industry considered as "inherently defensive" for change [15]. There is evidence that the construction industry is falling behind other sectors in its attitude towards sustainability [16]. The progress in the field has been hindered by many barriers, such as the industry's fragmented nature, lack of long term perspective, clients' unwillingness to share burden, lack of clear concept definition of sustainable construction and its benefits, regulatory constraints and inconsistent government policy, and lack of fiscal incentives [16, 17, 18].

3. Some knowledge gaps

3.1 Conceptualisation

Some of the recently published material in the literature perceives sustainability as an environmental problem. Consequently, the balance that needs to be created between the environmental dimension and other sustainability dimensions is not adequately acknowledged. There is also a noticeable lack of consensus on the issues underpinning sustainability and its dimensions. Hill and Bowen and Ofori point out that sustainability principles are still poorly defined and argue that these principles are subject to much confusion and disagreement [6, 7]. Ofori [6] argue that this could even be extended to the frequently quoted definition of sustainable development offered by The World Commission on Environment and Development. Lack of understanding and fuzziness of the concept present one of the barriers to the implementation of sustainable construction [17]. Further work, therefore, is still needed to better conceptualise sustainable construction.

3.2 Linking to the project life cycle

Sustainable construction could be better understood if it is aligned to the different phases of the project life cycle. From an implementation point of view, it would be more appropriate to provide such alignment [19]. Among the efforts that addressed sustainability within phases of the project life cycle are: Kibert [20], where the different project phases were integrated within a model for sustainable construction; the publication "Sustainability Accounting in the Construction Industry" [21], where a sustainability accounting plan considered the different phases of the project; Ashworth and Langston [22], where whole of life assessment was linked to the measurement of sustainability. However, there still seems lack of understanding regarding how the principles underpinning the different dimensions of sustainability could fit within the different phases of the project life cycle and what impact this issue could have on the different activities carried out within these phases.

3.3 Linking to project management

Project management could provide a suitable framework to implement sustainable construction, and project managers, through their leading role in the project, could be in an ideal position to promote it [19]. However, there is little evidence that sufficient research has been carried out to establish clear linkages between sustainable construction and project management. An examination of a summary of the UK Association of Project Management's Body of Knowledge [23] would indicate that sustainability does not feature as one of the key topics in that body. It is important to mention here that some of the topics addressed there – such as safety, health and environment; and value management are closely related to sustainability. Yet, they do not provide sufficient coverage of all the issues underpinning it. One of the few attempts to link sustainability to project management was carried out by Uher who developed a project management model for achieving sustainable construction and presented the need to integrate sustainable construction into the traditional project delivery strategy, which is constrained by time, cost and quality objectives [19]. The model developed by Uher focused only on the conceptual stage of the project life cycle. Further work linking sustainability and project management and considering the different phases in the project life cycle is still needed.

3.4 Implementation Mechanisms and Tools

A significant part of the literature discussed the principles of sustainability without sufficient consideration of how they could be implemented, an issue that was also raised by Uher [19]. More work is needed to identify implementation mechanisms and tools and to identify how sustainability could be integrated in the decision making process.

Sustainability has different dimensions and criteria which might be in conflict sometimes. An assessment of sustainability needs to take into account the different criteria underpinning it. This could lead to the use of multi-criteria decision making techniques for assessment. Such techniques were used for solving problems in construction management [24] and selecting construction procurement strategy [25]. In some cases, multi-criteria decision making was used with sustainability provided the basis for choosing criteria for decision making, as in developing SWARD [26]. There is potential to use such techniques to make informed decisions that consider sustainability criteria in problems such as selection of contractor or choice of procurement system [4].

3.5 Sustainability and Procurement

The need for introducing sustainability principles to construction procurement has been increasingly acknowledged. Some publications have addressed many useful issues in the context of sustainability and procurement e.g. the Sustainability Action Plan [27] and Addis and Talbot [28]. However, there still seems a need for further research within that area. For example, the framework developed in the Sustainability Action Plan [27] is based on 10 themes for action. Although these themes provide many useful sustainability principles in general, they do not embrace other principles mentioned in the literature, such as those presented in Tables 1, 2, 3. A more comprehensive and up to date list of the criteria representing sustainable construction that should be addressed is therefore needed. In addition, there is a need to examine procurement systems and strategies in terms of the extent of addressing the objectives of sustainability dimensions. Further research regarding the actions through which sustainability can be better addressed in developing procurement strategies and the barriers facing such actions is still needed. The gap was further discussed in Sourani and Sohail [4].

4. Dimensions of sustainable construction

Despite the variance between the different definitions of sustainability, there is a wide acceptance that sustainable development integrates, at least, three dimensions: social, economic and environmental. Some publications in the literature have mentioned other dimensions of sustainability such as technical sustainability [7, 26], cultural sustainability [6, 15], community sustainability [6] and managerial sustainability [6]. However, in the context of the UK construction industry, the concept of the triple bottom line, which focuses on social, economic and environmental sustainability, remains dominant. Some of criteria underpinning such dimensions are presented below. However, they are rather general guidelines to explore the areas of focus within these dimensions. More effort is still needed to reach a common understanding of the issues representing these dimensions, highlighting the relevance of such issues to the different parties, linking them to the project life cycle and defining how they can be addressed within this cycle. Further research is suggested below to contribute to the effort needed to achieve these targets.

Table 1: Criteria representing the social dimension of sustainable construction

Social sustainability criteria	**Sources**
Protecting and promoting human health through a healthy and safe working environment	[7, 17, 26, 27, 29]
Participation of stakeholders – including community involvement	[15, 17, 26, 27, 28, 30]
Improving the quality of human life including poverty alleviation	[7, 15, 31]
Making provision for social self determination/enhancement	[7, 15]
Training and development – including implementing skills training and capacity enhancement of disadvantaged people	[7, 12, 29]
Seeking fair or equitable distribution of the social costs and benefits of construction – including equal opportunities among different ethnic and social groups	[7, 31]
Seeking intergenerational equity and reducing cost for future generations	[7, 31]
Diversity - including making provision for cultural diversity in development planning	[7, 17, 29, 31]
Social inclusion	[15, 26, 28]
Improving image/reputation	[12, 29]
Employment – including equal employment opportunities	[12, 17, 30]
Recruitment and retention	[27, 29]
Equality	[15, 27, 29, 31]
Accessibility	[12, 28, 30]
Work in occupied premises	[17, 29, 32]
Working environment	[18, 27, 29, 32]
Security – including minimising crime	[17, 28, 30]
Satisfaction – including workforce satisfaction and user satisfaction.	[17, 18, 27, 28, 29]

Table 2: Criteria representing the economic dimension of sustainable construction

Economic sustainability criteria	**Sources**
Financial affordability for intended beneficiaries	[7, 26]
Maintaining high and stable levels of economic growth	[3, 12]
Using life cycle costing	[18, 26, 30, 32]
Creating and maintaining high and stable levels of employment	[3, 7, 12, 28, 31]
Support of local economies	[15, 18]
Investment – including investing some of the proceeds of non-renewable resources to meet the needs of future generations. Investment in green products and in the use of renewable resources.	[7, 31]
Use of Key Performance Indicators (KPIs)	[18, 32]
DQI - Functionality and Flexibility	[18, 30]
Viability	[18, 28]
Profitability	[2, 12, 17]
Competitiveness	[2, 12, 7, 17]
Productivity	[17, 18]
Value for money	[17, 18, 30]

Table 3: Criteria representing the environmental dimension of sustainable construction

Environmental sustainability criteria	**Sources**
Conserve energy	[7, 12, 17, 18, 28, 30, 31]
Conserve water	[7, 12, 17, 18, 28, 30]
Conserve land	[7, 12, 17, 18, 28, 30]
Conserve materials – reuse and recycling	[7, 12, 17, 18, 28, 30, 31]
Resource utilisation	[7, 26, 28, 30]
Consider renewable energy	[7, 17, 18, 30]
Minimise pollution – water, land and air pollution (including noise) – at global and local levels	[7, 12, 17, 18, 28, 30]
Preserve and enhance bio-diversity	[7, 12, 17, 18, 30]
Creating a healthy, non-toxic environment – including high indoor air quality	[7, 18, 20, 30, 31]
Protect and enhance sensitive landscapes including scenic, cultural, historical and architectural	[7, 17, 18, 28, 30]
Re-use existing built assets	[12, 18, 30]
Waste minimisation and management	[7, 12, 17, 18, 28, 30, 31]
Environmental Impact (process and product)	[18, 26, 30, 32]
Transport – including provision of public transport	[18, 30]
Visual impact	[17, 28]

5. Further research

Further research will focus on developing a common understanding of the criteria representing the social, the economic and the environmental dimensions of sustainable construction that public clients should address in developing procurement strategy. This will contribute to overcoming some of the knowledge gaps outlined above in terms of consensus and conceptualisation, linking to procurement as one of the stages in the project life cycle, and linking the to public clients as one of the parties concerned. The Delphi Technique will be used to confirm and evaluate criteria obtained from the literature review and the experts' responses and to derive a consensus, among sustainability experts, regarding the most important criteria

6. Conclusion

Sustainable construction describes the application of sustainable development in the construction industry. As the needs and the conditions of the developed countries are widely different from those of the developing world, the interpretation and the priorities of sustainable construction could be largely dependent on the context. However, regardless of the context, sustainable construction always integrates different dimensions, including social, economic and environmental dimensions. The progress in the field has been hindered by many barriers such as the industry's fragmented nature, lack of long term perspective, clients' unwillingness to share burden and lack of awareness, which seems to be problematic in both the developed and the developing worlds. The paper explored some of the knowledge gaps related to the subject including conceptualisation, linkages to project life cycle, linkages to project management, implementation mechanisms and tools, and construction procurement. It reviewed the criteria underpinning the social, the economic and the environmental dimensions of sustainable construction through a synthesis of the relevant literature. More effort is still needed to reach a common understanding of the criteria, to highlight the relevance of the criteria to the different parties, to link them to the project life cycle, and to identify how they can be addressed within this cycle. Finally, to contribute to achieving such targets, the use of the Delphi technique is suggested to obtain a consensus among experts regarding sustainability criteria that should be addressed by public clients in developing a procurement strategy.

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Harnessing the Role of FM in the Design Processes Through Post-occupancy Evaluation Studies

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Abstract

In delivering value services to buildings' clients/users, it is vital to gauge building occupants' feed back through post occupancy evaluation studies and walk-through at completion of a project. Such studies are rarely taken in the building industry in the UK apparently for cost reason. On the other hand, there is inkling in the facilities management profession that their role is marginalised particularly during the design processes of buildings contrary to the emerging notion of integration of FM in the design processes of projects. Post-occupancy evaluation studies will help to understand the role of facilities managers not only in the running and maintenance of facilities but further harness their role from initial inception of a project as well as establishing new performance indicators. Post-occupancy evaluation studies were carried out for various buildings including building with innovative sustainability design measures such as the application of hybrid natural and mechanical ventilation technologies. Indoor air quality parameters (temperature, humidity and CO_2) and external wind conditions, temperature, humidity and solar radiation were monitored for the investigated buildings. Structured occupants' surveys and informal interviews with occupants, facility managers and building designers were conducted.

The monitoring results for a building employing hybrid natural ventilation and air-conditioning systems showed that the indoor air quality parameters were kept within the design target range. Due to the short-falls in the control strategy for the hybrid system implemented, it was found difficult to quantify and verify the contribution of the natural ventilation to the internal conditions and, hence, energy savings. It was concluded that the value service for client/users was compromised due to the lack of facilities managers and system and software engineers involvement at early stages of the design processes in the buildings studied. System and software engineers for the building services control were consulted to devise the systems after the completion of the project. It was evident there was a lack of communication between designers, facilities managers and system and software engineers. This has lead to the failure of the control strategies and under-achievement of the full potential of the innovative technologies employed in the design of the buildings. Which further calls for a more holistic life cycle design approach for projects with genuine involvement of FM and IT specialist at the early stage of the design processes.

Keywords: Post-occupancy evaluation, hybrid systems, facilities management, building management system, wind catchers and indoor air quality

1 Introduction

Designing for comfortable internal conditions in buildings is a necessary goal for occupants' good health, well-being and high productivity. The application of passive design principles can help to achieve this goal with less energy consumption and at no extra cost to the building. Such passive design principles include the employment of wind catchers for natural ventilation in buildings. Predictive design tools are commonly used during the early design stage for sizing of systems. These prediction tools, such as thermal models and CFD, are based on steady state conditions and cannot accurately establish the performance of ventilation components in building, particularly when the external and internal conditions are transient and occupants' pattern and activities are changing [1]. It is critically important to gauge building occupants' feed back through post occupancy evaluation studies. Such studies are, rarely taken in the building industry in the UK for cost reason. Government's initiative such as the Building Regulations future performance certification of buildings, air pressurisation and thermo-graphic testing promote such studies to develop energy performance indicators for new and existing buildings [2].

The wind catcher/tower system is a passive ventilation system which not only extracts air using passive stack principles but also utilises the concept of a wind tower to supply air to the spaces as well. Traditionally, wind catchers were employed in buildings in the Middle East for many centuries and they are known by different names in different parts of the region. They were constructed, traditionally, from wood-reinforced masonry with openings at height above the building roof ranging from 2 m to 20 m. With taller towers capturing winds at higher speeds and with less dust [3]. Their application in the hot arid region of the Middle East is to provide for natural ventilation/passive cooling and hence thermal comfort. Wind catchers are traditionally used in places of high urban densities where surrounding buildings obstruct free stream air flow. Traditional wind catchers can be beautiful objects, feasible architectural feature additions to buildings and are inherently durable [4, 5].

In modern design of wind catchers, the two ventilation principles of wind tower and passive stack are combined in one design around a stack that is divided into two halves or four quadrants with the division running the full length of the stack. As the wind direction changes so do the functions of each of the halves or the quadrants in the wind catcher. This renders the wind catcher as being operational whichever way the wind is blowing. As there are no free parts to the wind catchers, their maintenance is very small. It has the benefit of taking supply air at roof level, which is often cleaner than air supplied at ground level, particularly where the building is adjacent to a road in urban areas [5].

Post-occupancy performance evaluation of indoor environment in buildings where innovative technologies such as wind catchers are installed will assist in validating the systems and test their applicability in buildings for natural ventilation. The subjective assessment of occupants' satisfaction with indoor air quality and their ability to control the operation of wind catcher, hence controlling their environment, is an important criteria in validating the application of the hybrid air-conditioning and wind catchers. Furthermore, such studies will enable the understanding of the success/failures in the design and operation for such systems. This further will provide vital information and knowledge for designer and facilities managers. In this paper, sample quantative results of post-occupancy evaluation studies for two buildings are discussed. The two buildings are the Bluewater Shopping Malls, Kent, and the Seminar Room at the School of Construction Management and Engineering building.

2 Description of Buildings

2.1 Bluewater Shopping Malls

Bluewater Shopping Malls in Kent are newly constructed, out off town, shopping malls. The buildings incorporate wind catchers to ventilate the malls. The wind catcher cowl is inspired by the old form of a Kent oats houses as seen in Figure 1. These forms of oats houses were widely used in the area and became an architectural feature in modern buildings around Kent. The building is an innovative application for wind catchers in the UK and provides the opportunity for validating the application of wind catchers in a temperate climate, such as the UK. The building is managed via an Integrated Building Management System. The wind catchers are automatically controlled in conjunction with mechanical ventilation system.

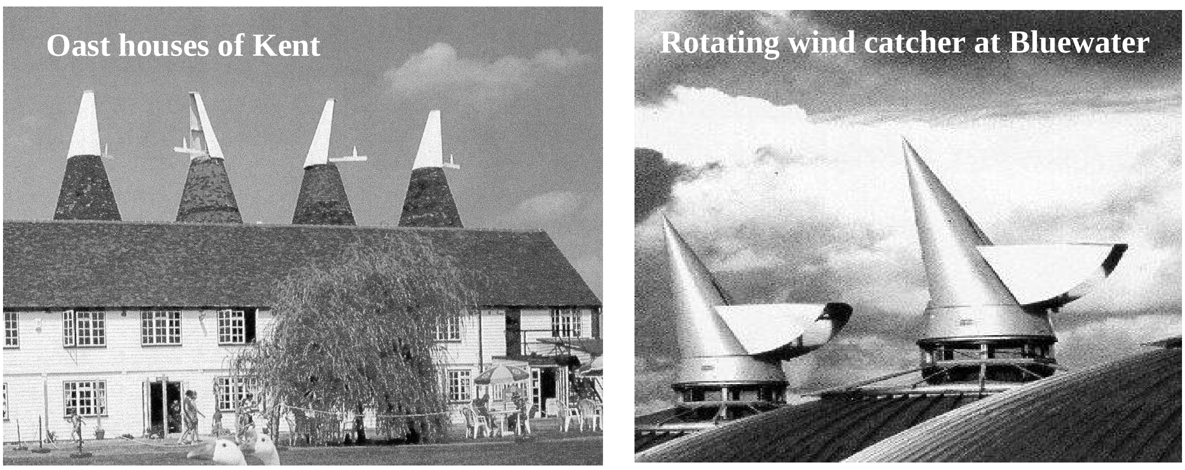

Figure 1: Traditional and modern rotating wind catcher at Bluewater shopping malls, Kent

The Bluewater building consists of three rectilinear form shopping malls with other reception halls and ancinary services (Figure 2). The three malls are forming a triangular shape with south, west and east facing malls and service courtyard in between. Shops were distributed around the three mall streets over two floors. The malls were ventilated using a mixed mode of natural ventilation applying wind catchers and air-conditioning system using the air handling units located on the roof of the buildings. There are 39 rotating wind catcher units distributed along the malls (13 units in each mall street). The performance investigation is carried out by taking the centre of each mall as a monitoring point. Indoor air quality parameters such as temperature, humidity and CO_2 level were controlled by the AHU units.

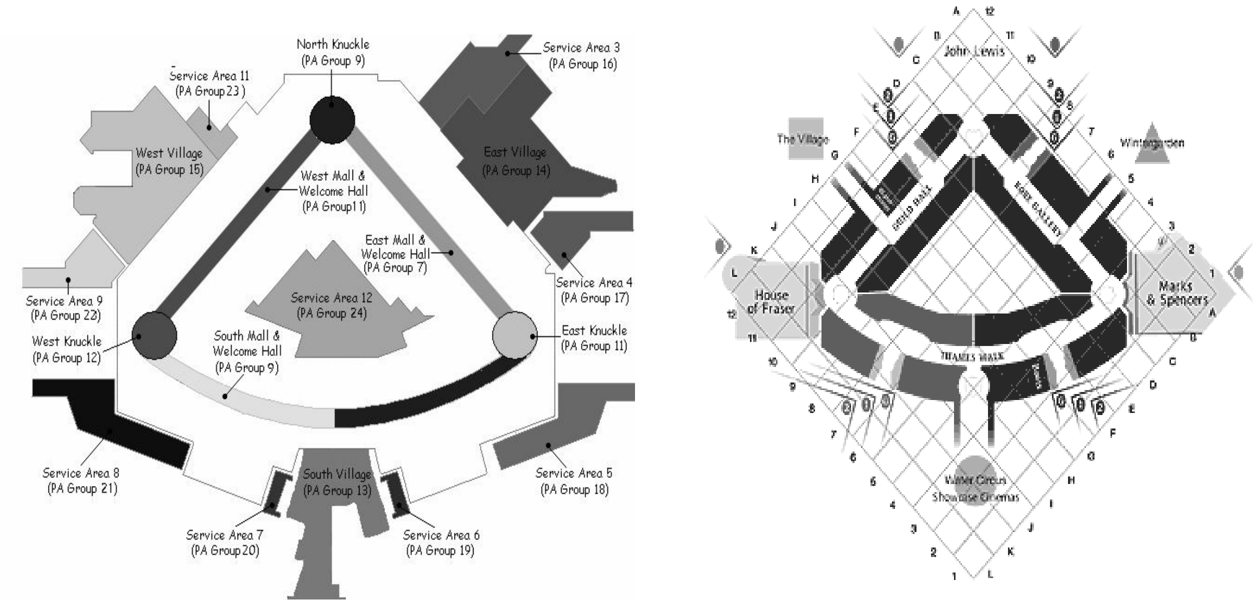

Figure 2: Plans of the shopping malls at Bluewater, Kent

2.2 The Seminar Room 2n09

A combined wind catcher and light pipe (Sun Catcher) was installed in a seminar room at the University of Reading, UK. The 3 storey building was constructed in 1973 and has a split level. It has a rectangular form with two offices running along two corridors, north and south, with atria, service cores and offices in between. The seminar room was newly refurbished and located in the second floor on the North side of the building with a floor area of approximately 61 m^2 and a volume of 211 m^3. The room's external and internal walls are light cream paint blockwork with a pitch roof of 2.5°. The room floor is composed of carpeted concrete with a false ceiling giving a floor to ceiling height of approximately 3.5 m. Two windows are located in the north wall of the seminar room and at adjacent bays each side of the concrete beam in the middle of the room. The windows extend from 1 m above floor level to ceiling providing a glazed area of 1.8x2.5 m. The room's IT area includes 5 computers with intermittent use. Figure 3 shows internal views of the seminar room with the wind catcher segments surrounding the internal light pipe diffuser (Figure 3 a1). The position of the wind catcher in relation to the windows is shown in Figure 3 a2. External view of the wind catcher terminal with the external light pipe translucent dome is shown in Figure 3b. The wind catcher system (1x1x1.5 m) is constructed from glass reinforced plastic with four segments, surrounding the 550 mm diameter light pipe, each with an area of 0.191 m^2 and a total duct area of 0.764 m^2. Each segment was fitted with manual dampers for air flow control operated at ceiling level.

Figure 3: Position of the wind catcher in the seminar room

Indoor air quality parameters were monitored inside the room at two different points. In the centre of the room, internal temperature, humidity and CO_2 concentration were measured using Automatikproducter (AP) and Onset HOBO H08-007-02 indoor air quality logging system. At monitoring point 2 (adjacent to the computer suite) internal temperature and humidity were measured using a complete Davis Vantage Pro weather station, which measure all external conditions including temperature, humidity, wind speed and direction, atmospheric pressure, rain and solar radiations. The weather station is located at the top of the building (2 m above building level, 15 m above ground level and 75 m above sea level). Both the Automatikproducter (AP) and Onset HOBO and the weather station were connected to a PC to facilitate data recording. The Solomat 4100 indoor air quality monitor and data from the weather station at the Metrology Department, the University of Reading, were also used as cross reference with the Davis Vantage Pro weather station data. The measurement of air change rate was carried out using the tracer gas decay method. SF_6 (Sulphur Hexaflouride) was used with CBISS 12 points Intelligent Sampling System (MK2) connected to Brüel and Kjaer (INNOVA) single gas analyser type 3425.

3 Results and Discussions

3.1 Bluewater Shopping Malls

The Integrated Building Management System (IBMS) provided the interface for operating all building equipment and their operations. The system is mainly used to check on the operation of the equipment. Alarms were sent to the IBMS console about any failure and malfunctioning of the equipment such as the air handling units and wind catchers. The IBMS log external weather conditions parameters, AHU status and operation data and internal air quality parameters at an interval of 15 minutes. The IBMS system has been operational for more than three years.

The recorded data is saved into MS Access software. The database is then interrogated via a program in MS Excel developed using MS Visual Basic programming tool. The Excel program provide the data required for any week in the year. The saved database for the year 2001 was interrogated and analysed to investigate the operation of the ventilation system and establish the performance of wind catchers at one central point in each malls street (south, west and east malls). Particularly, their contribution to the indoor air environment and energy savings achieved if any. For investigating the summer operation the database was interrogated for different weeks in the summer period. Figure 4 gives the results for one week in August in the south mall street. The indoor air quality monitors were kept within the design target providing acceptable indoor air environments for the shoppers. The CO_2 never exceeded 1000 ppm, which is an acceptable level according to ASHRAE recommendations [6].

To investigate the co-ordinated operation of the wind catchers with the AHU, fan pressures were plotted across the external wind speed, external temperature and humidity. The results show that the fan pressure was at its highest, approximately 130 Pa, while the recorded external wind speed at its peak with a recorded maximum measurement of 3.7 m/s (Figure 5). It was well established by observation that all the wind catchers units were facing the prevailing wind direction. The results show that in all the malls the fans were at their highest operations at the same time the external wind speed was in the range of 1-3 m/s for the full wind catchers' operation, hence not reducing fan pressure by operation of the wind catchers. This was due to the lack of co-ordination between wind catchers and the AU which is not considered in the IBMS system. This control system failure greatly emphasises the need for the inclusion of facilities managers, software and system engineers at the early stage of the design of the project, i.e. at day one in the inception of the project.

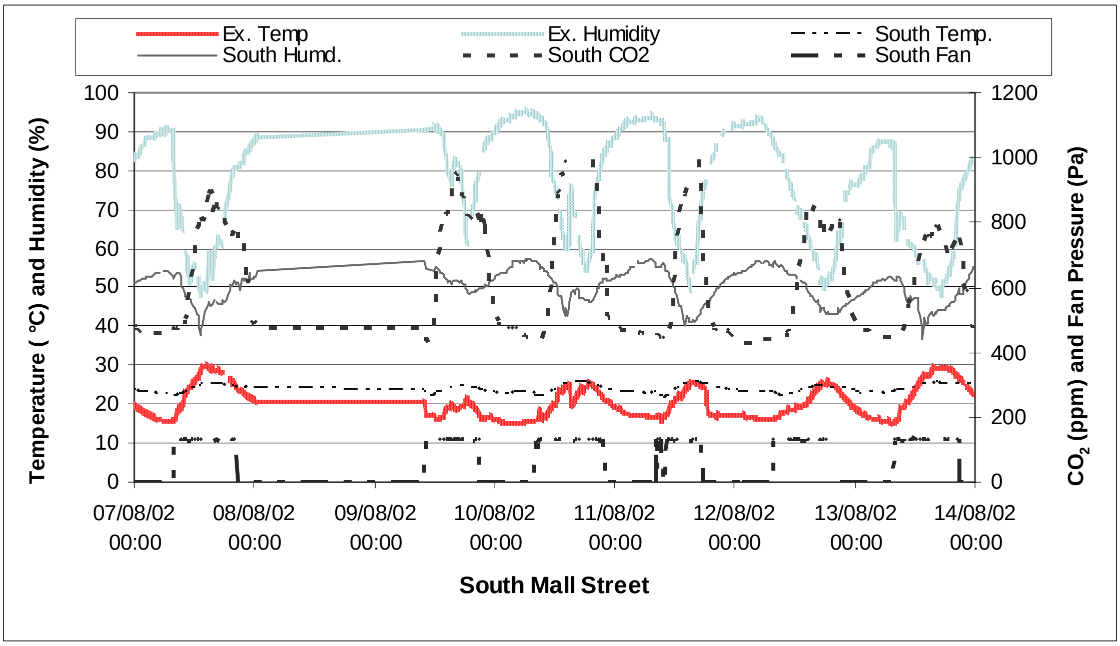

Figure 4: Measured indoor air quality parameters and fan pressure in the centre of the south mall street

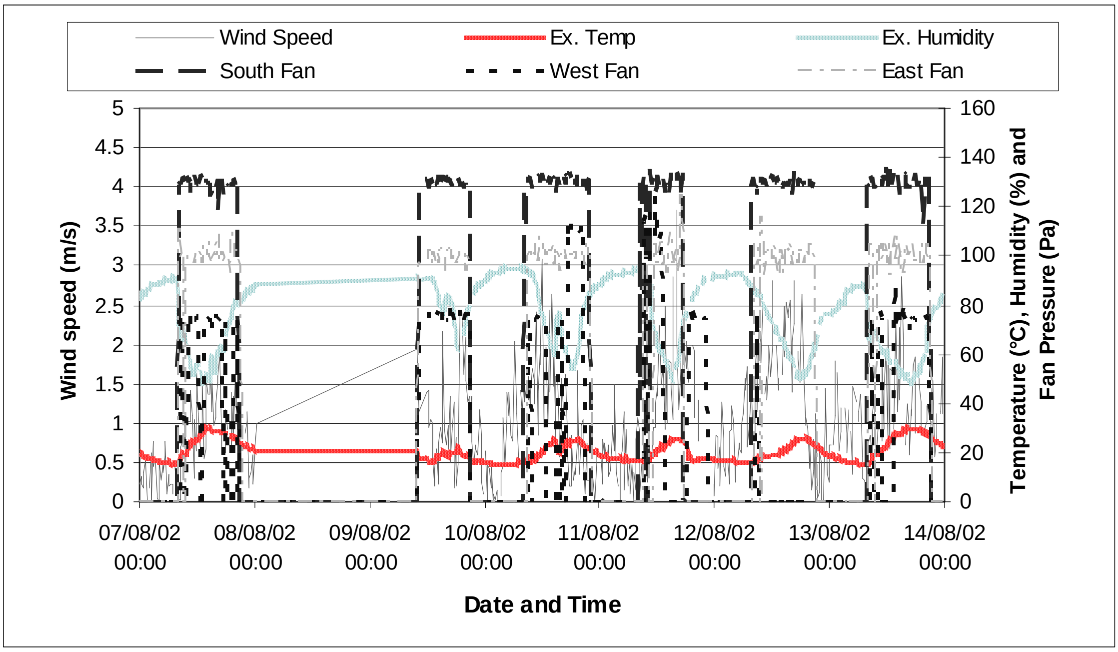

Figure 5: Plotted external wind speed against fan pressure and external temperature and humidity

3.2 The Seminar Room 2n09

3.2.1 Monitoring Results

The wind catcher was tested with dampers fully open and half open while the windows were closed. Tests were also carried out with windows open half the full size (1.8 x 0.212 m) and full size (1.8 x 0.424m) of the wind catcher duct area of 0.762 m^2. The results of two cases are presented in this paper. Case 1: wind catcher dampers fully open/ windows open half duct area during the month of August. Case 2: wind catcher dampers fully open/ windows open full duct area during the month of September.

The combined effect of wind catcher when fully open with open windows was investigated in Case 1 test during the month of August. The size of open windows area was half the size of the duct area of the wind catcher. Figure 6 shows the results for the test in Case 1. While internal humidity and CO_2 levels were maintained at an acceptable level, the internal temperature is higher was higher due to the high external temperature. The combined effect of window/wind catcher operation reduces the internal temperature adjacent to the window. The difference between internal and external temperature was at least 3 °C. The CO_2 level inside the room did not exceed 500 ppm. This is below the ASHRAE recommendations of CO_2 concentration of 1000 ppm [6]. Furthermore, in this case (Case 1), tests were conducted to evaluate the ventilation rate using tracer gas measurement. Further tests for ventilation rate in the afternoon were carried out to establish the validity of tracer decay method in analysing the ventilation rate. Generally speaking the ventilation rate increased during the night and the early hours of the morning and reduced during the warm afternoon as can be seen in Figure 6. This is due to higher temperature difference and relatively high wind speed in the night, thus confirming the suitability of applying wind catchers/towers for night time ventilation in buildings.

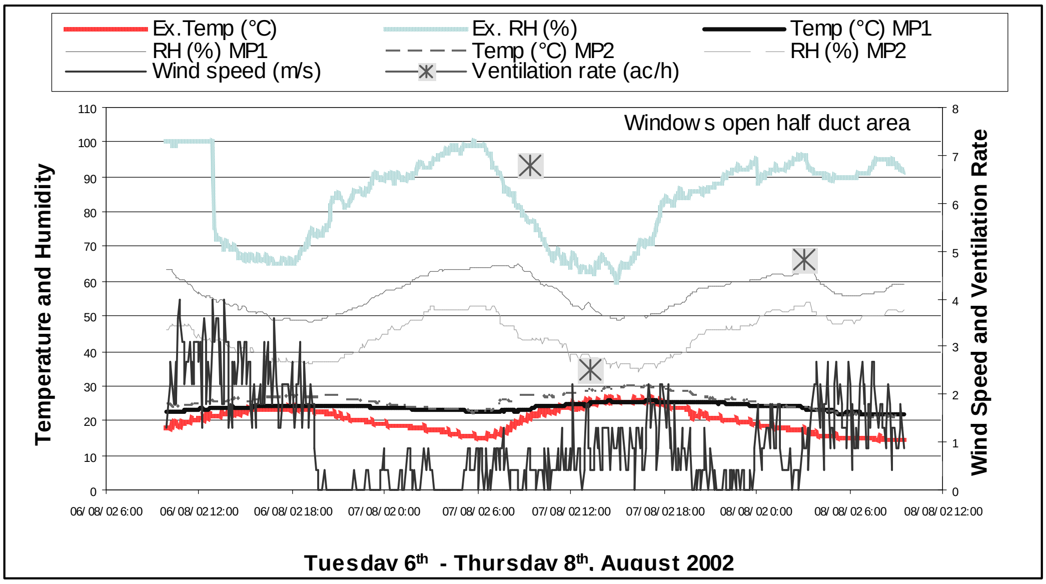

Figure 6: Variation of the measured ventilation rate, wind speed and indoor air quality parameters

The measured local ventilation rates in both conditions of window opening size in this Case show little or no variation when the windows were open the full wind catcher duct area. If the window open area is reduced to half the size of the wind catcher duct area some variation in the localised ventilation rate was observed particularly during the night. The ventilation rate was slightly lower by the window (SP4, 1.6 ac/h). Such a ventilation rate is considered to be insufficient when compared with the CIBSE recommendation of 6-10 ac/h.

Table 1 gives the measured ventilation rate, thermal and indoor air quality parameters in the repeated tests for Case 1. The results showed that the ventilation rate (hence, the performance of the wind catcher) depends on the wind speed and direction. The repeated tests for the ventilation rate in the afternoons gave similar results in a range of 2 – 2.5 ac/h as in the previous tests. The analysis of these results, (taking into consideration the variation of external conditions) showed no discrepancies in air change rate, thus establishing the applicability of tracer gas decay method in measuring air change rate for wind catchers. However, the overall building performance is more complex and depends on other variables, such as the thermal mass of the building, air infiltration through the fabric in addition to windows and the wind catcher opened areas.

Table 1: Averaged measured indoor air quality, thermal and ventilation parameters, repeated Case 1 (windows closed).

Date and time	**ventilation rate ac/h (average)**	**Temp diff**	**Wind speed m/s**	**Direction**	**Ex.Temp (°C)**	**Ex. RH (%)**	**Temp MP1 (°C)**	**RH MP1 (%)**	**CO_2 ppm**	**Solar Rad. (W/m^2**
Afternoon 23/07/2002 1 5:52- 18:40	**1.4 (82 l/s)**	**5.3**	**2.8**	**W**	**18.7**	**81.1**	**24.0**	**59.0**	**488.4**	**143.1**
Night 23/07/2002 20:30:- 23:29	**2.3 (135 l/s)**	**7.1**	**2.0**	**W**	**17.1**	**81.8**	**24.2**	**55.1**	**469.2**	**2.3**
Morning 24/07/2002 00:08 - 03:08	**3.5 (205 l/s)**	**8.0**	**1.0**	**NNE**	**16.2**	**82.1**	**24.2**	**53.0**	**411.6**	**0.0**

In Case 2, the size of the opened window area was increased from half to full duct area. Figure 7 shows the measured indoor air quality parameters in Case 2. The monitored indoor air quality parameters were kept within acceptable levels. The measured ventilation rate in the night was lower than in the afternoon despite the higher temperature difference and slightly higher wind speed. This can only be explained by the variation in wind direction. The ventilation rate is dependent on temperature difference, wind speed and wind direction and, hence, the established performance of wind catchers. However, in some cases the ventilation rate was found to be insufficient with values of 2-5 ac/h compare with the calculated ventilation requirement of 11 ac/h.

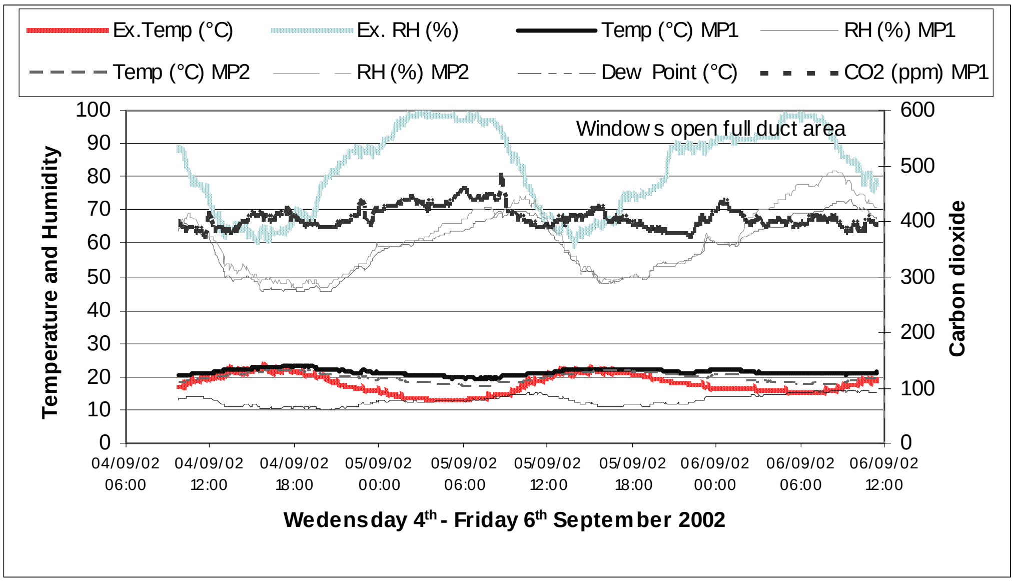

Figure 7: Measured indoor air quality parameters in with windows open full wind catcher duct area, Case 2

3.2.2 Occupants Survey

The study of subjective assessment of the indoor environment in the Seminar Room 2n09 was conducted using structured questionnaire. The questionnaire was structured around four main areas; personal details, thermal environment, visual environment and overall environment in the seminar room. For the data entry, data manipulation and statistical analysis, SPSS software for Windows was used. SPSS is a package developed originally for social scientists using large mainframe computers. Since then it has been refined and redeveloped for different types of computer architecture including Windows [7].

Table 2 gives the nationality versus overall thermal conditions cross tabulation. The majority of the occupants were neutral (41.7%), one third of the occupants felt significantly warm, and 16.7% of the occupants felt only slightly warm. The distribution of overall thermal comfort in conjunction with age is shown in Figure 8. It shows that the majority of occupants in the age range 20 – 40 felt neutral to slightly warm. With regard to the recommendations of the installation of the wind catcher and light pipes systems, 75% of the occupants surveyed welcomed the application of the system for natural ventilation and daylighting in buildings. The same percentage found the air movement inside the room to be acceptable. Interestingly, although 25% of the occupants found the air to be stagnant they still welcomed the installation of wind catchers. This could be due to the environmental awareness of the occupants and their desire to apply renewable energy and low energy architecture systems in buildings. Furthermore, through informal interviews many occupants of the seminar room expressed their satisfaction with the performance of the wind catcher and they changed their sitting area to be under and around the wind catcher in the summer months of 2002.

Table 2: Distribution of nationality with overall thermal conditions

Nationality * Overall thermal conditions Crosstabulation

			Overall thermal conditions				
			warm	slightly warm	neutral	slightly cool	Total
Nationality	British	Count	1		1	1	3
		% within Nationality	33.3%		33.3%	33.3%	100.0%
	Sudanese	Count			1		1
		% within Nationality			100.0%		100.0%
	Chinese	Count	1		1		2
		% within Nationality	50.0%		50.0%		100.0%
	Western Europe	Count			1		1
		% within Nationality			100.0%		100.0%
	Korean	Count		2			2
		% within Nationality		100.0%			100.0%
	Turkish	Count			1		1
		% within Nationality			100.0%		100.0%
	Taiwanese	Count	1				1
		% within Nationality	100.0%				100.0%
	Malaysian	Count	1				1
		% within Nationality	100.0%				100.0%
Total		Count	4	2	5	1	12
		% within Nationality	33.3%	16.7%	41.7%	8.3%	100.0%

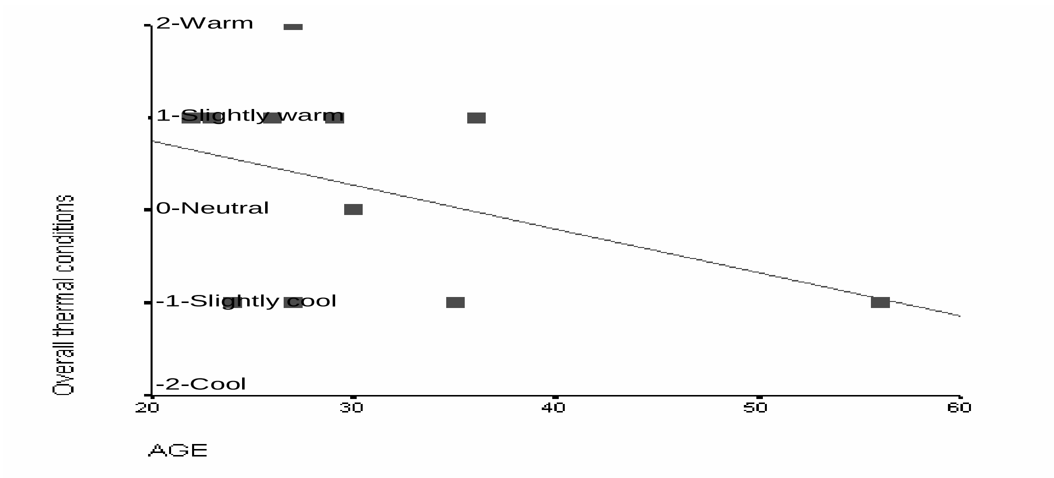

Figure 8: Distribution of overall thermal comfort with age of occupants

4 Conclusions

Post-occupancy evaluation studies enable the validation of building design processes and operation. Such studies will enable emerging concept of learning from use, which facilitate much needed integrative approach for building design and operation. Particularly, integration of FM and software and system engineers at early stage of the design processes. In this paper post-occupancy evaluation studies were carried out into two buildings; Bluewater Shopping Malls in Kent and the Seminar Room 2n09 at the School of Construction Management and Engineering. Monitoring of indoor environment in real weather conditions was conducted to evaluate the indoor air quality within the buildings together with an occupant survey.

The Bluewater Shopping Malls in Kent provided an innovative application of a wind catchers integrated with the mechanical ventilation system (hybrid). The integrated system is controlled via the Integrated Building Management System (IBMS) which recorded all external and internal parameters into a computer database. The summer month operation showed that the indoor air quality parameters were kept within the design target range. It showed that the fans came into operation whenever the CO_2 level was reaching a set-point of 1000 ppm. The operation of the fan increased the ventilation rate and hence reduced the CO_2 concentration to the recommended value. While the wind catchers were operational, no data was recorded regarding their operation, opening time and position. Though the control strategy implemented was working effectively in monitoring the operation of mechanical ventilation systems, i.e. AHU, it did not cover the integration of the natural ventilation system, i.e. wind catchers, with the mechanical ventilation. Controlling the operation of the wind catchers via the AHU led to isolation of these systems in the event of malfunctioning of the AHU, hence the wind catchers will remain shut. Due to the shortcoming of the control strategy implemented in this project, it was found difficult to quantify and verify the contribution of the natural ventilation systems (wind catchers) to the internal conditions and, hence, energy savings.

The monitoring results and occupant survey conducted in a University seminar room showed that indoor air quality parameters were found to be within acceptable level when the wind catcher was operating. The air change rate measured was in the range of 1.5 ac/h to 6.8 ac/h. These results were complemented with occupants' survey analysis where 75% of the occupants welcomed the installation of wind catchers systems.

The results of the monitored buildings emphasised the importance of harnessing the pivotal role of facilities managers and software engineers in the early stage of design. Looking beyond the figures, post-occupancy evaluation studies provide an ideal tool for processes improvements and understanding of behavioural changes through the various stages of the construction cycle of a project. The studies will provide indispensable knowledge and information to be incorporated into new project and thus achieving the goal of client/user centred integrative design and service delivery.

5 Acknowledgement

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The Growth of Environmental Requirements in International Facility Management

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Abstract

In the service and light industry (SLI) companies have already realised that the use of facilities causes a large share of their environmental burden. This study presents typical environmental objectives within the largest companies operating in the SLI and investigates whether these companies have specified facilities (facility management) as a high priority issue when minimizing company's environmental impacts. In addition, the study aims to determine whether there has been any increase in environmental requirements for facilities management organizations in recent years. We found that the most typical environmental objectives in SLIs are reduction of electricity consumption, waste recycling/re-use, waste minimisation and reduction of climate change emissions, all of which are closely related to the use of the facilities. At present, one third of the companies studied emphasize the role of facilities in their environmental management. When comparing the results between the years 2003 and 2005, we see that the most typical environmental objectives have changed and that more companies have explicitly stated the environmentally important role of facilities or facility management.

Keywords: environmental management, environmental objective, comparison, facility management, service industry

1. Introduction

Corporate social responsibility (CSR) and sustainability are of growing importance for companies operating in the service and light industries (SLIs). For example, the number of organisations certified according to the ISO 14001 environmental management certificate increased thirty-four per cent in the year 2003 to over 66 000, the highest number ever [1]. Companies also publish significantly more CSR reports than they did some years ago [2] [3], and, for instance, over fifty per cent of companies listed in Fortune Global 500 publish environmental reports [4]. CSR includes several fundamental elements, of which the most important are a company's duty to openly report its environmental performance and to minimise its environmental impacts. Recent studies have disclosed that, in the SLI, a large part of the environmental burden of companies is most likely caused by the facilities themselves [5].

Furthermore, it has been suggested that facility management (FM) should have the key role of environmental management of SLI companies, since facilities represent less than ten per cent of company expenses but cause almost a half of the environmental impact of the SLI organisation [6].

Several studies have been conducted about companies' environmental reporting but on a more detailed level environmental management is less studied [7]. Only a few studies have analysed SLI companies' environmental management from the facilities or FM's point of view. In one such study, SLI companies were found not to explicitly state facilities in their environmental management, but yet their most common environmental objectives related closely to the use of facilities [8]. From society's standpoint, SLI companies, such as banks, are an important group of companies and the potential for reducing the environmental impacts of SLI companies has been found to be significant [5].

This study presents the most typical environmental objectives within the largest companies operating in the SLI and investigates whether these companies have specified facilities (FM) as a high priority issue when minimizing company's environmental impacts. In addition, the study aims to determine whether there has been any increase in environmental requirements for facilities management organizations in recent years.

2. Method, material and selection of companies

The study is based on the case study method and environmental information published by SLI companies. The study was carried out as a multiple-case study and by using a time series design. The study has an exploratory approach and embedded units of analysis. [10] Each company represents a case and each named objective an embedded unit of analysis. The data collected related to both qualitative environmental objectives (i.e. to reduce energy consumption, environmental risks) as well as quantitative ones (i.e. the use of energy [GWh], CO_2 emissions [tons]). The data was entered into a matrix and each environmental objective analysed. Quantitative environmental objectives were separated out from qualitative objectives and then the data was analysed by country and by industry sector, special attention being paid to the recognition of facilities FM. Finally, the results were compared with a similar study conducted in the year 2003 and published in 2004 [8].

Altogether, thirty-one SLI companies were included in the study. The companies were selected as being among the five largest, based on turnover, in their respective area, and as having published environmental information. The largest companies were selected because "they are highly visible to stakeholder groups and are often presented as examples of environmental behaviour of the industry as a whole" [11]. The selected companies were the same as those in a previous similar study to obtain better comparability. However, two companies have changed since 2003 because of corporate fusions, so new companies replaced the old ones (Sonera > TeliaSonera, SCC Scandiaconsult > Ramboll) [12][13].

The companies represent three different geographical and four industrial areas. Of these companies, eleven are Finnish, ten European and ten from the USA, and the industry sectors are represented as follows: banks and insurance (eight); trade (eight); ICT (nine); consulting (six). European and American companies were selected on the basis of the Fortune Global 500 list [14], and Finnish companies on the basis of the Talouselämä 500 list [15] (in Finland Talouselämä is equivalent to Fortune or Business Week). European and American consulting companies, however, were selected on the basis of one consulting company's peer group [16], because typically the turnover of consulting companies is too small to reach the Fortune 500 list. Selected companies are presented in Table 1. by country of origin and industry sector.

The study is based on publicly available environmental information on the Internet pages of the companies. Besides Internet pages, the data used also include other available documents on the Internet, like annual, sustainability or CSR reports. The data were mostly collected in the autumn 2004 and reviewed in February 2005.

Table 1: Companies included in the study.

	Finland	**Europe**	**United States**
Banking and insurances	Sampo	AXA	Citigroup
	Tapiola	Allianz	Bank of America
	Nordea	ING Group	
Trade	Kesko	Kingfisher	Target
	SOK	Pinaul-Printemps	The Home Depot
	Stockmann		Wal-Mart
ICT	TeliaSonera	Deutshe Telekom	Motorola
	Nokia	Vodafone	Verizon
	Elisa	France Télékom	Microsoft
Consulting services	Jaakko Pöyry Group	Amec	SNC-Lavalin Group
	Accenture	Ramboll	Jacobs Engineering Group

3. Results

3.1 The most common environmental objectives

In this results section companies' environmental objectives are analyzed first in general and then by companies' geographical and industrial sector distribution. After that, the change in companies' environmental objectives, and the role of facilities and FM, are analyzed. Environmental objectives of each studied company are presented in Table 2.

Almost every company, about ninety per cent, uses environmental objectives, and, surprisingly, about sixty per cent of companies measure their environmental performance by using quantitative environmental objectives (Table 3.). The use of quantitative environmental objectives, in general, is considered as a sing of better capability to manage environmental

impacts, and therefore declare organisation's commitment to environmental management. Companies who have the most reported qualitative and quantitative environmental objectives are Kesko, AXA, Nokia and Deutsche Telekom.

Table 2: Environmental objectives recognized by a company. An empty box (□) indicates a qualitative objective and a full box (■) a quantitative one. A thin square ( ) around a box indicates a positive change and an X a negative change compared to year 2003.

OBJECTIVE / **COMPANY**	Sampo	Tapiola	Nordea	Kesko	SOK	Stockmann	TeliaSonera	Nokia	Elisa	Jaakko Pöyry Group	Accenture	AXA	Allianz	ING Group	Kingfisher	Pinault-Printemps	Deutshe Telekom	Vodafone	France Télékom	Amec	Ramboll	Citigroup	Bank of America	The Home Depot	Target	Wal-Mart	Motorola	Verizon	Microsoft	SNC-Lavalin Group	Jacobs Engineering Group
ENVIRONMENTAL IMPACTS																															
climate change				g			g	g				g	g	g	c		[g]	g	[g]	g		g	[c]		[c]		[g]	[g]			
acidification				g			X	[g]																							
summer smog				g	X		X																				g				
ozone depletion substances								g										g				X					[g]				
particles				g			X																								
ENERGY																															
heat	g	g		g	X		X	g				g	g				[g]		c			g									
electricity	g	g	c	g	X	c	c	g				g	g	g	c	g	g	g	g	c	c	g	[g]	c	c	c	g	c			
NATURAL RESOURCES																															
material				g								g					c						c	c			c			c	
water	g	g		g	X		X	g				g	g	g		g	[g]	c				g		c			g	[g]			
paper	g	g											g	[c]		[c]	g	g			c		g								
TRAFFIC																															
commuting / travelling		c	c				c					g	g	[g]			g	g	g			[g]	c								
transportation / distribution		c		g	c	c	c								c	[c]															
WASTE																															
waste (general)	c	g		g	c		X	g				g	g	g	c	[c]	g	g		g		g			c	c	c	c			
packaging				g	g	[c]									c									c			c		[c]		
several waste components	c		X	g	c		X					g					[g]										[g]	[g]			
MISCELLANEOUS																															
facilities, FM, or real estates	c	[c]		c	c							[c]	c	[c]			c											[c]	[c]		
waste recycling / re-use	c	g	c	[g]	[c]	c		g					[c]				[g]	[g]		c	c	[g]	[c]	c	[g]		[g]	c	[c]		
environmental risks			c		c														c				c	c							
environmental education	c		c						c				c											c						c	
following the legislation	c		c			c			c								c	c	c					c	c		c	c	c	c	
environmental purchasing	[c]	c	c	c			X	c	c			c	c	c	c	[c]	c	c			c	c					c				
visual impacts of masts							c										c	c	c												
other objectives			c			[c]		[g]				[g]	[g]	[c]	c	[c]	c	[g]		c	[c]	[c]	c	c			[c]	[c]			

Table 3: Number of environmentally active companies selected for the study, and the use of environmental objectives in each respective area.

	Number of companies	No objectives	Qualitative objectives	Quantitative objectives
Geographical				
Finland	11	2	11	8
Europe	11	0	11	9
USA	10	1	9	5
Industry sectors				
Bank and insurance	8	0	7	8
Trade	8	0	8	4
ICT	9	0	9	7
Consulting	6	3	2	1

Companies are emphasizing several environmental objectives as a part of their CSR, and the most typical environmental objective in SLI seems to be the reduction of electricity consumption. Almost every company has emphasized it in its environmental management, and over half of the companies also measure their electricity consumption. Other common environmental objectives are waste recycling/re-use and waste minimization. As well, reduction of climate change emissions, environmental requirements in purchasing and minimal water usage are often seen important.

When the results are analyzed in geographically, we see that European companies have recognized more environmental objectives than Finnish and US companies. The difference between European and Finnish companies is, however, quite small if compared with the difference between European and US companies. This is especially true in the use of quantitative environmental objectives. In addition to the most typical environmental objectives, each area also has its own characteristics. Most studied European companies focus on climate change, and in most cases company has a quantitative climate change indicator. In Finland attention is paid to waste recycling/re-use, environmental purchasing and heat energy whereas US companies find recycling/re-use and following the legislation important. The most common environmental objectives in studied geographical areas are presented in Table 4.

Table 4: The most common environmental objectives in Finland, Europe and in the United States.

Finland	Europe	USA
Electricity	Electricity	Electricity
Waste recycling / re-use	Climate Change	Waste recycling / re-use
Heat	Waste	Legislation
Water	Environmental purchasing	Climate Change
Waste	Water	Waste
	Paper	
	Commuting	

Differences exist also between the industry sectors. Banks and insurance companies, ICT companies and trade companies are all almost equally active in their environmental management. The consulting sector is a more passive industry sector, and three consulting companies have no environmental objectives. Excluding consulting, each industry sector has some typical objectives. For instance, banks and insurance companies are interested in commuting, paper use, and environmental requirements in purchasing, while trade companies focus on transportation/distribution and packaging. ICT companies communicate that they follow legislation and are especially interested in minimizing their climate change emissions. It should be noted that all studied ICT are measuring their climate change emissions. The most common environmental objectives in each industry sector are presented in Table 5.

3.2 The change in environmental objectives

Companies' environmental objectives presented in this paper are now compared with the results of similar study, which was published in the year 2004, and which is based on data collected in the year 2003 [8]. We see that SLI companies have now recognized more environmental objectives

Table 5: The most common environmental objectives in each industry sector. The following objectives were equally common in each sector. Banks and insurance: waste, recycling/re-use, water; Trade: transportation/distribution, packaging, recycling/re-use; ICT: climate change, legislation; Consulting: Electricity, recycling/re-use; ALL: climate change, purchasing.

Bank and insurance	**Trade**	**ICT**	**Consulting**	**ALL**
Electricity	Electricity	Electricity	Electricity	Electricity
Environmental Purchasing	Waste	Climate Change	Recycling / re-use	Recycling / re-use
Waste	Transportation / distribution	Legislation		Waste
Recycling / re-use	Packaging	Recycling / re-use		Climate Change
Water	Recycling/re-			Purchasing Water

than in the year earlier. This study evaluated 22 most common environmental objectives, from which fourteen are nowadays used more often than earlier. These are waste recycling/re-use, reduction of climate change emissions and facilities. Facilities is used as a qualitative objective, probably because quantitative measurement is challenging. Some objectives are used less than earlier (Figure 3.).

However, the number of companies, which have recognised environmental objectives, has not changed, so the development has taken place in previously active companies. Companies who have enhanced most the reporting of their environmental objectives are Motorola, Deutche Telekom and Pinault-Printemps Reroute. By contrast, some companies, i.e. TeliaSonera and SOK, share now less environmental information than earlier, mostly because of company fusions.

The total number of environmental objectives emphasized by a company has also risen. Geographically, both European and US companies seem to measure their environmental performance more today than earlier, whereas the studied Finnish companies appear to now use less quantitative environmental indicators (Figure 1.). The trend to use qualitative environmental objectives seems to be mounting in all geographical areas. This trend is also seen when industry sectors are compared; and further it holds true for quantitative environmental objectives. Banks and insurance companies have adapted most new qualitative indicators, and they also seem to measure their environmental performance more than other industry sectors. The consulting sector is an exception since no development can be seen in there. The most remarkable change in environmental objectives has occurred among ICT companies who are emphasizing reduction of climate change emissions and waste recycling/re-use more strongly then earlier (Figure 2.).

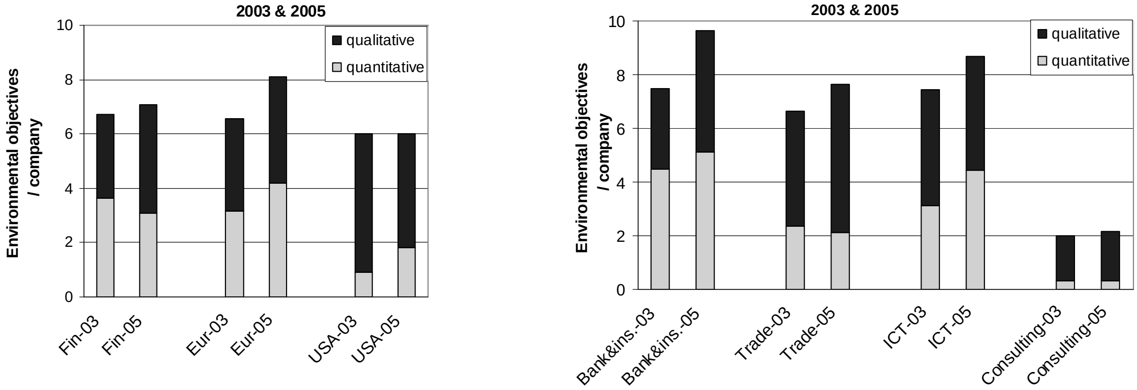

Figure 1. & 2: The number of environmental objectives in Finnish, European and US companies and in different industry sectors in the years 2003 and 2005.

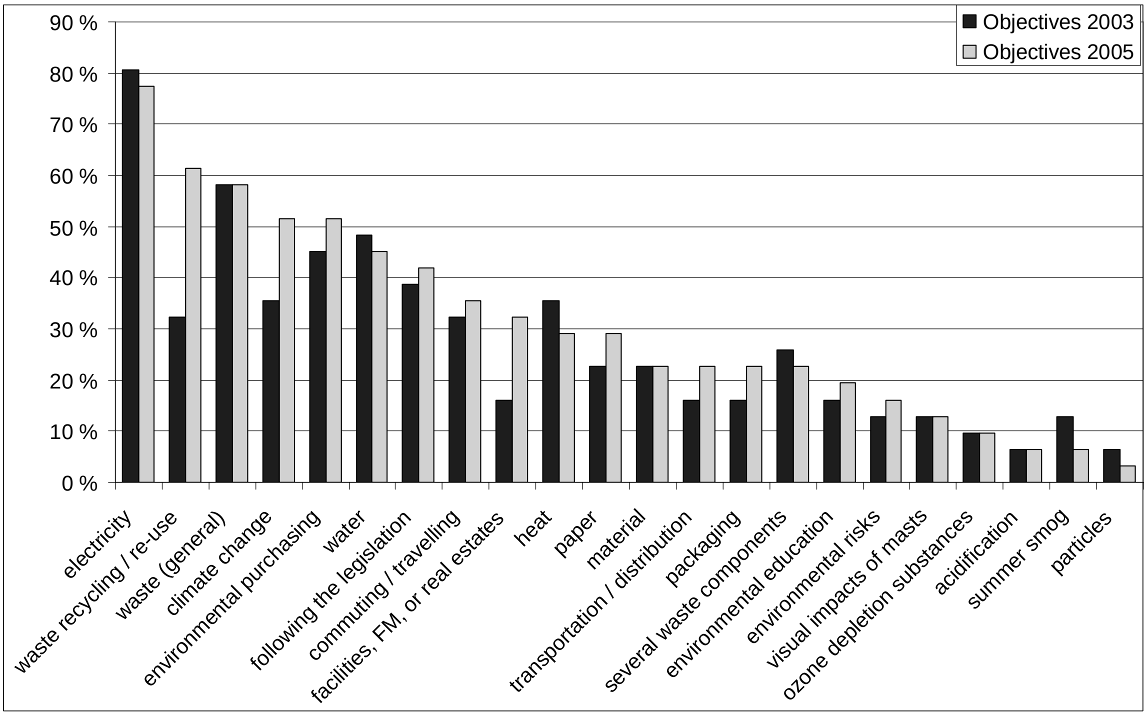

Figure 3: Environmental objectives used by the SLI companies in 2003 and 2005.

Generally speaking, companies have improved their environmental reporting. Most companies, 21 out of 31, have enhanced the available environmental information in their Internet sites. Typically, the companies have improved the availability of quantitative environmental information. Many companies have also activated in their CSR during the last two years, and they are now publishing CSR-reports, using the Global Reporting Initiative (GRI) Guidelines, and striving for a certified environmental management system.

3.3 The role of facilities and facility management

At present, ten out of thirty-one companies have explicitly stated performance of facilities/ facility management as an environmental objective. Four of these companies are Finnish, four

European and two American; five are banks and insurance companies, two are trade companies, and three are ICT companies.

Surprisingly, the greatest growth among all environmental objectives has taken place in facilities/FM. The number of companies who have explicitly stated facilities/FM as an environmental objective doubled since 2003. In contrast, environmental requirements in purchasing, for example, increased very modestly (Figure 4.). The increased focus on facilities, and also on waste management/re-use, indicates that companies aim to improve the environmental performance of concrete and ordinary matters.

Furthermore, some facilities recognized companies are very strongly accentuated facilities or FM in their environmental management. The companies have, for instance, environmental programs and life-cycle objectives especially for facilities, and companies, such as Microsoft and SOK, are using or exploiting building environmental certification systems. Moreover, some companies who have not explicitly stated facilities in their environmental management, are, for example, paying attention to energy usage, implementing building management applications, and even performing energy audits in their buildings. It seems that these companies have indirectly recognised the important role of facilities from the environmental management point of view.

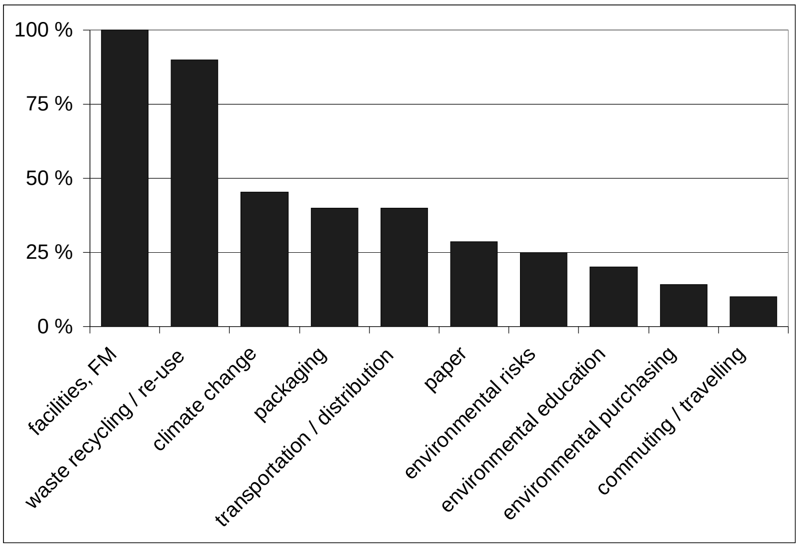

Figure 4: Increase in the use of environmental objectives between 2003 and 2005.

4. Discussion

This study presented the most typical environmental objectives within the largest companies operating in SLI, and investigated whether facilities or facility management have been specified as an environmentally high priority issue in these companies. In addition, the study aimed to determine whether there has been any growth in environmental requirements set for facilities management organization in recent years.

The role of facilities and FM in SLI companies' environmental management is clearly increasing. The number of companies who have explicitly stated facilities in their environmental objectives doubled during the last two years, being now roughly one third of companies. SLI companies are taking a more and more comprehensive viewpoint towards environmental issues, and their most typical environmental objectives are reduction of electricity consumption, recycling/re-use, waste minimization and reduction of climate change emissions. European companies have improved their environmental reporting more than US companies, which in general seem to be less active in their environmental management. However, companies with smaller turnover may not see CRS as important as large companies, and they might be less willing to invest in it. This may be the case also with studied consulting companies.

Buildings sustainability, or environmental performance, is universally becoming a more and more important issue. Interestingly, in the US, the use of the building environmental certification system (LEED) has grown over 30 per cent in 2003 [17], and green buildings are a hot topic in the construction and real estate sector. This study showed a notable increase in the status of facilities in companies' environmental management, which suggests that in the future the importance of facilities and FM will be even more widely accepted, when SLI companies aim to minimize their environmental impacts and emissions. It has already being stated, perhaps commercially, that "senior management will start to see the value of having facility managers who are skilled in green buildings" [17].

Some limitations can be recognised. First, the main limitation relates to the use of only one source of evidence. According to Yin [10], the quality of a case study is always improved when several sources of evidence are used. Second, the selection of companies from each industry sector may have caused distortions because different industrial sector classification is used in Fortune and Talouselämä magazines. The third limitation stems from the very diverse interpretations of the concept "environmental objective". In some companies, environmental objectives are understood as very practical and strict instructions, whereas in others, they are seen as wide-ranging, general statements. Also, companies don't communicate their environmental objectives clearly and unambiguously.

5. Conclusions

Companies' environmental responsibility is becoming an increasingly important issue, and companies are realising the importance of facilities and facility management from the environmental management point of view. This may result in significant changes in the needs and expectations the facility users (e.g. SLI companies) have for facility owners, facility managers and facility service providers.

The practical implications of the results are probably the most substantive for facility and real estate companies. These companies should take advantage of the results when improving their operational practices, planning their future strategies and developing their services.

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Refuse Collection Facilities and Health Concerns in Dense Urban Residential Buildings

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Abstract

Refuse collection facilities and the related management are of particular importance to dense urban residential buildings because they are normally congested and high-rise with noted difficulties with vertical transportation. The issues in concern include property management, cooperation from and convenience of the residents, technology and cost benefit of the facilities. All the efforts in the refuse collection management aim to provide a pleasant and hygienic environment for the resident. However, there is little in-depth study carried out to examine the relationship between the refuse collection facilities and their impact of the health of the residents. This topic was brought to focus after the recent outbreak of the atypical pneumonia, known as SARS in Asia in 2003. Peoples in the region were more concern about their built environment and its impact of their health. This paper present the findings of a study carried out in Hong Kong which compared the popular traditional refuse collection systems and the more advanced automatic refuse collection system. The study was carried out with particular reference to the health issues of the residents. The study found that apart from the consideration of cost, technology and efficiency of the facilities, management of the facilities is the most critical for the success of a refuse collection system.

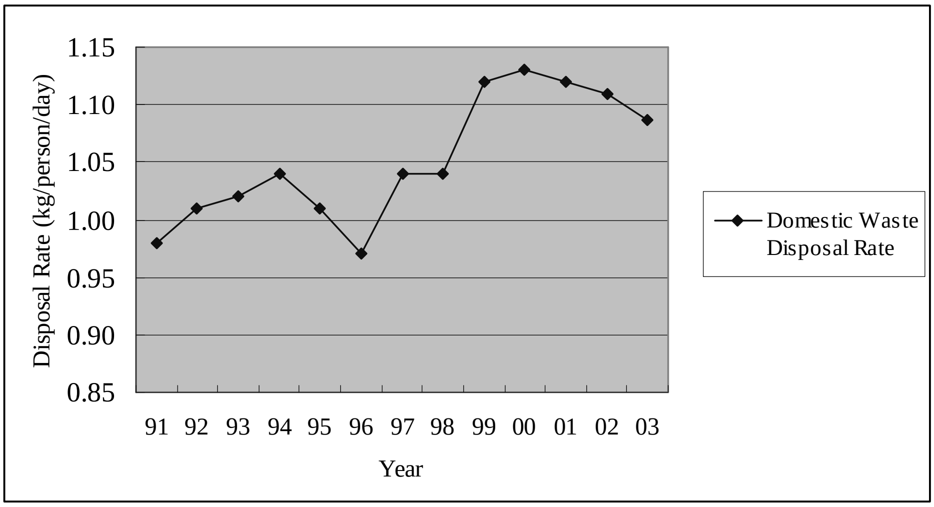
Keywords: Healthy Building, Refuse Collection, Management, Facilities, Residential

1. Background

After recent outbreak of the atypical pneumonia, known as SARS in Asia in 2003, the public concern about protecting human health and preserving the quality of their living environment had been aroused. As refuse collection facilities are widely recognized as hotbeds of bacteria cultivation, it is worth to examine the relationship between the refuse collection facilities and their impact of the health of the residents, and recommend some ways to improve the refuse collection management in order to provide a pleasant and hygienic environment for the residents. Nevertheless, little in-depth studies are carried out to investigate this issue. This paper present the findings of a study carried out in Hong Kong which compared the popular traditional refuse collection systems and the more advanced automatic refuse collection system, identified the social acceptability and financial viability of those systems, and developed guiding solutions for refuse collection management.

1.1 Overview

Everyday, thousand tonnes of refuse from residences (known as domestic wastes) are generated in Hong Kong [3]. Figure 1 has shown the disposal rates of domestic waste per capita in 1991-2003. Obviously, such huge amount of refuse not only affects the living environment of the citizens but also impose health risks on them and the cleansing workers. Numbers of previous researches indicated that health hazard would be generated from the process of refuse collection [6, 7, 10, 12]. Sigsgaard (1994) also reported that Danish refuse collectors were prone to suffer from allergies, infections and respiratory problems. In order to minimize nuisance and health risk to the cleansing workers, the residents and their living environment induced by huge amount of domestic wastes, refuse should be disposed of properly [8].



Source: Environmental Protection Department (2004a)

Figure 1: Per capita disposal rates of domestic waste in 1991-2003

2. Conventional Refuse Collection Systems VS Automated Refuse Collection System

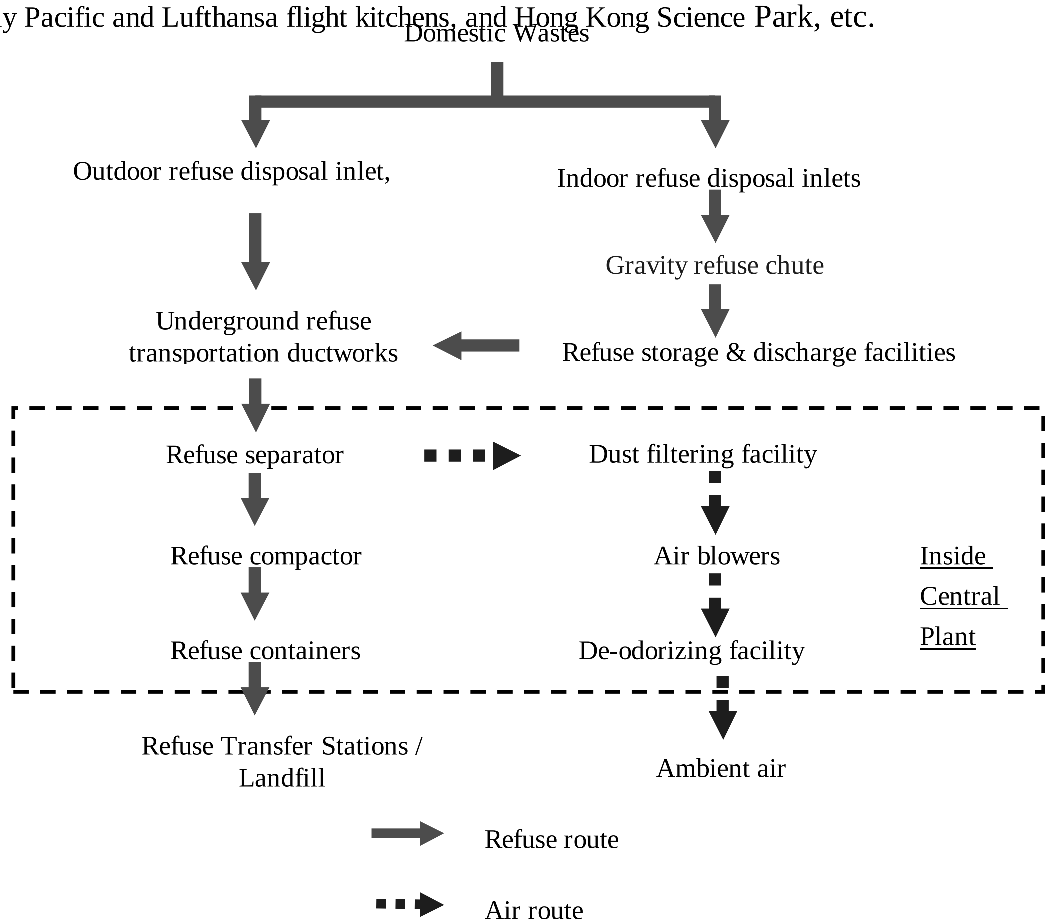
2.1 Conventional Refuse Collection Systems

Conventional Refuse Collection Systems (CRCS) are traditional refuse collection methods commonly adopted in Hong Kong throughout the years. There are two types of CRCS: one with refuse chute and the other without. For the residential developments with the provision of refuse chutes, the occupants either dump their refuse directly to refuse chute or dispose the refuse at designated areas on each floor. The cleansing contractors then collect their refuse to refuse room on each floor and dumped the wastes to the refuse chute through indoor refuse disposal inlets. The refuse collection bin under the chute would store the refuse temporarily. The cleansing workers transport the refuse collection bins inside the refuse chambers located at G/F of different blocks manually to the central refuse collection point where Food and Environmental Hygiene Department (FEHD) collects refuse daily at predetermined time. For the buildings without refuse chute provision, the residents dispose their refuse at specified locations on each floor. The cleansing workers collect the refuse and package them into larger plastic bags or place them into the collection bins. Then, the bags or the bins will be conveyed to the ground floor by passenger or goods lifts.

2.2 Automated Refuse Collection System

Automated Refuse Collection System (ARCS) is a more advanced type of refuse collection system. It is controlled by centralized and computerized programs [5]. The refuse dumped through indoor refuse disposal inlets on different floors to the refuse chute or outdoor refuse disposal inlets is temporarily stored in refuse storage facilities. The sensors will be triggered once the storage facilities are full and refuse released from the refuse discharge valves will then be transported to the central plant room through underground ductworks by suction of air. The refuse enters into the cyclone type refuse separator which separates the air and refuse for further treatment. The exhaust air is discharged to ambient air after treatment by de-odorizing facilities like carbon filter or chemical scrubber while the refuse is compacted and stored in a refuse container ready for disposal (Figure 2).

ARCS is not a new device for refuse collection in Hong Kong property market. In mid-1990s, the Hong Kong Housing Authority (HKHA) had implemented two ARCS pilot schemes at Wah Sum Estate and King Shing Court and at Shek Yam East Estate respectively. As this system was subjected to positive comments and had enhanced the living environment at that time, HKHA had approved the adoption of ARCS as a standard provision for future public housing estates and Home Ownership Scheme (HOS) courts to enhance their sanitary and environmental conditions since 1998 [4]. Besides, this system was also adopted in several private commercial projects in Hong Kong. For examples, ARCS are installed in Hong Kong & Shanghai Bank Headquarters, Cathay Pacific and Lufthansa flight kitchens, and Hong Kong Science Park, etc.



Source: Hong Kong Housing Authority (2003)

Figure 2: Routing of refuse and air in ARCS

2.3 Comparison between Two Refuse Collection Methods

2.3.1 Characteristic of CRCS

(1) Low installation, operation and maintenance costs as it does not involve mechanical devices and construction of central plant and underground refuse conveying ductwork.

(2) Nuisances such as spills and odor would be generated probably during movement of refuse from each floor to the central collection point and loading of refuse from the refuse collection bins to the refuse collection vehicles that may pose health risk on the cleansing workers and the residents nearby.

(3) Bags containing refuse dumped into the refuse chute may break before reaching the refuse collection bin underneath or the refuse may throw everywhere in the refuse chamber when total amount of refuse is far beyond the holding capacity of the bin. Thus, the bin or the refuse chamber will be smeared with dirt and sanitary or hygienic problems are resulted.

2.3.2 Characteristic of ARCS

(1) ARCS is perceived as a more healthy operation for refuse treatment as the chances of emission of unpleasant smell and spill of refuse are significantly reduced when the refuse is transported in concealed ductworks and stored in containers for disposal.

(2) Total numbers of cleansing workers required under ARCS for conveying refuse from refuse chambers on G/F of each block to central collection point and loading the refuse to the refuse collection vehicle can be greatly reduced.

(3) Movement of noisy refuse collection vehicles and unpleasant odour generated from the refuse collection bins and vehicles can be eliminated. Hence, the overall image and appearance of our society can be improved.

(4) To connect all refuse chutes from different blocks to the central plant room, extensive underground conveying ductworks have to be provided, which pose difficulties in arrangement of the routings of various types of utility services.

(5) More underground spaces are required for accommodating refuse transportation piping.

(6) Provisions of underground refuse transportation pipe works and the central plant have increased the installation and maintenance costs. The Hong Kong Housing Authority revealed that the installation cost of ARCS is 10 times more than the initial cost of the conventional method.

(7) As the refuse is transported inside the ductworks by suction, and the refuse and exhaust air are treated by mechanical means, high running cost and energy consumption are expected.

(8) The chance of system breakdown due to mechanical failure is high that may affect normal refuse collection. Once the system fails, refuse should be handled manually and nuisance would be created.

Table 1: Results of comparison between characteristics of two systems

	CRCS	**ARCS**
Cost - ***Installation*** - ***Maintenance & Operation***	Low	High
Spatial Requirement	Moderate	Large (mainly U/G spaces)
Health Risk	High	Low
Nuisance Generated	Probably	Not probably
Labour Required	Intensive	Not intensive
Chance of System Breakdown	Low	High

3. Discussion

Although the comparison supports that ARCS prevails over the traditional method as it improves the living environment of the residents [11] and benefits the society as a whole, its popularity in Hong Kong residential development is still low comparative to CRCS. The major obstruction is due to high initial and running cost of ARCS (Table 2). As mentioned by the Hong Kong Housing Authority, the installation cost of ARCS is 10 times more than the initial cost of the conventional methods. Owing to the financial consideration, the Hong Kong Housing Authority has ceased to install ARCS in public estates recently.

Table 2: Installation, operation and maintenance costs for ARCS

	Installation Cost* **(per flat)**	**Operation & Maintenance Cost*** **(per flat per month)**
Hong Kong Housing Authority	$5,000	$30
ARCS Installer	--	$24
ARCS Supplier	$5,000	$25
Average Cost	**$5,000**	**$26**

* Costs obtained from projects of three parties with more than 3,000 flat units in a single development

Private sector also advised that it was not cost effective to install ARCS in private residential developments especially those in smaller scale after carrying out cost-benefit studies. The installation cost of ARCS could only be justified if there was sufficient numbers of flats in a development, and the operation and maintenance costs could also be reduced when there were certain amounts of residents to share the costs. However, most of the private residential developments nowadays are in small or middle scale; therefore, the installation cost per unit is much higher for private development. The developers have lower incentive to invest in ARCS and they give up this option for refuse management and adopt a cheaper acceptable alternative i.e. CRCS instead.

Apart from the installation cost, high operation and maintenance cost is also a reason making ARCS less attractive. ARCS is an automatic refuse collection device without heavily rely on people to dispose the refuse. It is supposed that the savings in labour cost can partially cover the additional operation and maintenance costs induced by ARCS. Nevertheless, the labour cost for handling refuse could not be reduced after using ARCS. The property management staff pointed out that self disposal was not preferable in Hong Kong especially in public housing estates because some residents would dispose substances that may damage the refuse chutes or cause fire accidents. Thus, cleansing workers were required to be employed to dump the refuse to the chutes for the occupants, and total running cost of ARCS including labour cost was still high.

4. Results of Questionnaire Survey

From late May to July 2004, questionnaire surveys to the residents living in public housing estate, sandwich class housing and private residential development were conducted and 651 numbers of questionnaires were returned. Nearly 80% of replies pinpointed that refuse collection methods would affect their health in large extent. Undoubtedly, many residents supported ARCS as they strongly believed that the system could improve their living environment. However, many of them were not willing to pay additional amounts for operating and maintaining the system. The results were summarized in Figure 3 and 4.

About 40% of respondents living in public housing estate believed that ARCS was the best refuse collection system; however, approx. 30% of them are happy to use CRCS (using refuse chutes) if additional amount of fee should be paid for ARCS. For the residents in sandwich class housing estate, 64% of respondents preferred ARCS and approx. 25% of respondent would like to adopt CRCS (using refuse chutes). About 63% of respondents in private residential development preferred ARCS and 32% of respondents preferred to use refuse chutes while 4% of them would like to use lifts to convey their refuse. The questionnaire survey perceived that the residents generally supported ARCS even though they were living in various types of housings. They believed that this system could minimize the nuisances generated by manual handling of refuse, eliminate negative health impacts on residents and cleansing workers, and enhance overall hygienic and sanitary conditions of their estates.

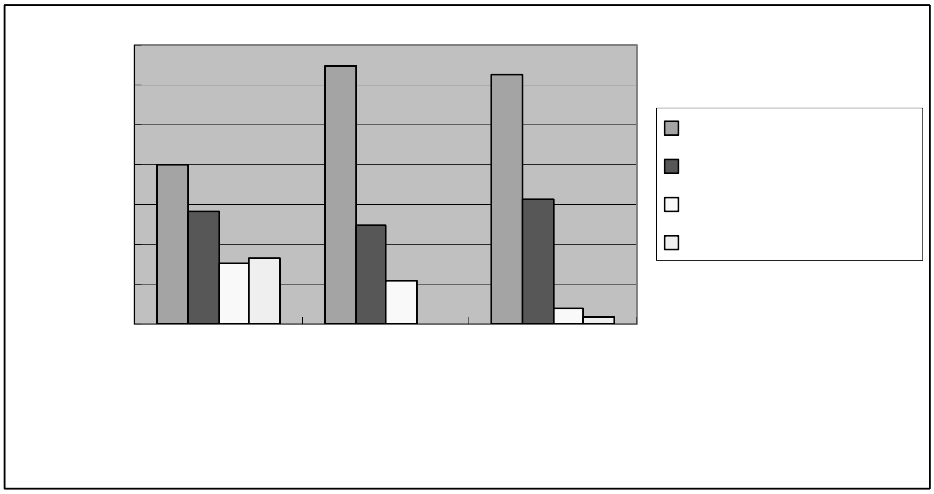


Figure 3: Residents' preference towards the refuse collection systems

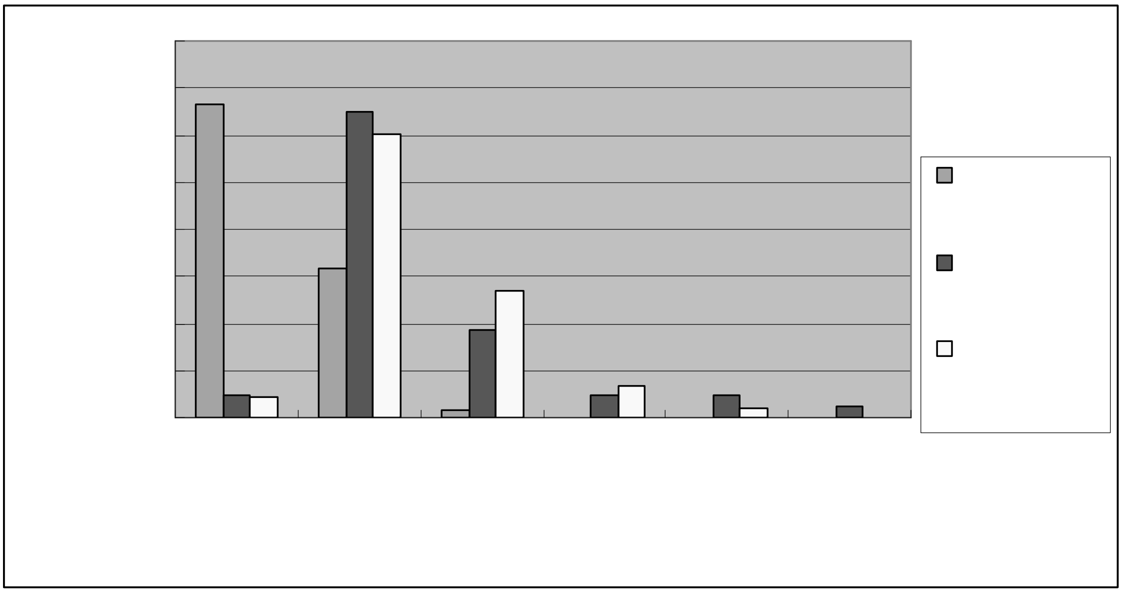


Figure 4: Willingness to pay for supporting ARCS

Nevertheless, majority of the respondents living in public housing estate would NOT like to pay additional amount to support the normal operation of ARCS. Some of them claimed that the Hong Kong Government was responsible to provide a healthy living environment for them and therefore, government should pay for installation, operation and maintenance of the system. If they had to share part of the cost of ARCS, they would prefer conventional system. That explained why there was significant amount (about 44%) of respondents selected conventional refuse collection system in the survey. For the respondents who were living in sandwich class housings and private residential buildings, most of them were willing to bear the cost for operating and maintaining ARCS; however, they only accepted a maximum increase of less than 5% in monthly management fee. With reference to the figure in Table.2, the average operation and maintenance cost per flat per month was about $26 only which could probably be covered by the maximum amount (i.e. 5% of existing amount of monthly management fee or rent) the residents were willing to pay. Hence, the developers have to justify the financial viability of the installation of ARCS solely before selection of the most suitable refuse collection method in their property development.

5. Recommendations

5.1 Importance of Proper Management

As afore said, the popularity of ARCS is low due to its high installation cost even though it is widely recognized that this system can enhance the environment when dealing with refuse. The developers cannot justify the cost to install this advanced refuse collection system and they prefer to adopt traditional system at this moment. To cope with the problems induced by the conventional refuse collection system, proper management of these facilities can help a lot. The nuisances can be minimized through proper building management by frequent cleaning of refuse rooms and chambers; replacement of refuse collection bin before reaching its holding capacity; using refuse collection bins with larger capacity; advance planning of the refuse transportation route in order to minimize the movement of bins and refuse collection vehicles in the estate, etc. In addition, self disposal can be promoted through property management to reduce the workload and health risk imposed on the cleansing workers as they are not required to expose to the refuse removing from the bin to the chute. In order to facilitate the owners or tenants to dispose the refuse through indoor refuse disposal inlets, contactless devices such as infra-red sensor and voice recognition device for opening them can also be installed to avoid disease transmission and possible contamination by direct contact.

Waste separation can also be promoted to reduce the total amount of household wastes generated in an estate. Through proper education by property management staff, most residents would discard general household rubbish directly into refuse chute and put recycled materials like paper, aluminum cans and plastic bottles in designated areas inside the refuse room. The cleansing contractors would collect the recycled materials and dispose other wastes at the bottom of the chutes for them. After implementation of the recycling scheme, it is believed that the cleansing contractors can earn more on top of their basic monthly salaries by selling recycled wastes. With incentives, the cleansing contractors are willing to take up the responsibility to collect those wastes. In this way, both cleansing workers and residents are benefited as the hygienic conditions are sustained and even improved when adopting conventional refuse collection system.

5.2 Other suggestions

(1) For those who would like to install ARCS in their developments, it is desirable to install it to serve several residential projects in the same district at the same time in order to spread the initial cost for installation of this system among estates. Each resident can also bear a smaller amount in operating and maintaining it.

(2) To minimize the risk of infection, refuse collectors should take injections regularly, such as tetanus shots and hepatitis B vaccine. They should wear protective gear like goggles, nose-and-mouth masks and heavy masks. They should also use clean water and towel to scrub themselves during breaks or after works [12]

(3) In-depth study on the impact of refuse collection methods on health and cost-benefit study should be carried out before drawing conclusion on promotion or adoption of ARCS. If it is scientifically proved that ARCS systems are the only way to solve the health problem imposed by the conventional refuse management system, ARCS systems should become essential installations even though their initial cost may be high.

6. Conclusions

The questionnaire survey pinpointed that many Hong Kong citizens concerned about their health and living conditions. As the residents believed that refuse treatment was one of the major factors affecting their health, they would support or prefer a refuse collection system that could treat the refuse in a more hygienic way i.e. ARCS. Nevertheless, they would not like to pay more money to support the operation of the system. Besides, there were other obstructions for promotion of this system. The developers found difficulties in determining break even point and could not justify the cost to install this system. Hence, the publicity of this system is low nowadays. It seems that the local practitioners and researchers still have a long way to go before having a technically feasible, economically viable and high efficiency proposal on refuse collection. This study provides an insight that good building management could address nuisance problems induced by refuse collection system. To enhance the living environment of the residents, more resources should be put on the management of existing refuse collection facilities.

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Section VI

Innovation and development in facilities management

The Nature of Innovation Climate in Facilities Management

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Abstract

Despite the abundance of research on innovation in organisations, very little is known about service innovation as opposed to product innovation. Novel developments in customer care, front-of-house FM and new ways of working share parallels with service innovations in other sectors where a change of process has profound effects. More specifically, little is known about the FM environment most likely to stimulate service innovation. This paper attempts to describe the emerging concept of 'innovation climate' and proposes using a measurement instrument to measure this phenomenon. The approach will enable characterisation of FM organisations in terms of their predisposal to innovate within the prevailing climate.

Keywords: Innovation climate, service innovation, innovation process

1. Background

This paper describes an ongoing study funded by the ICRC (Innovative Construction Research Centre) involving the participation of organisations in the Thames Valley region of the UK. An innovation network (BIFM Thames Valley FM Innovation Network) of around fifteen companies has provided a practical vehicle for the comparison of how FM teams in organisations engage in innovation. The Thames Valley is often described as the 'silicon valley' of the UK with a high preponderance of hi-tech organisations, although the network itself involves other client organisations including building societies, banks and service providers. Rather than simply providing a place for exchanging good ideas, the network sought to ask more fundamental questions about innovation in their organisations. What are the characteristics of a good FM innovation? What are the influencing factors that enable innovation? To answer these questions required a fundamental look at how FM individuals and teams function. Many of the organisations in the network were involved in radical and challenging innovations that often pushed the boundaries of FM activities. What were the features of these organisations that enabled them to achieve this?

2. Innovation in services

A number of recent research papers examining the nature of *service innovation* have highlighted the feasibility of testing such innovations in a scientific and controlled manner. Innovation in services has “emerged from Cinderella status, from being neglected and marginal, to achieving wide recognition as being worthy of serious study” (Miles, 2000). The perception of services as non-innovative activities has progressed to a widespread view that innovation can play a major role. This has resulted in increasing attention being paid to service innovations (Evangelista, 2000; Miles, 2000; Drejer, 2004; Tether, 2004) . The “laggard” classification of the service sector as being solely subject to client “pull” (Howells, 2000) has given way to a much more positive view of the sector in which a huge variety of complex and innovative activities go on (Hertog, 2000; Uchupalanan, 2000; Tether, 2003; Thomke, 2003; Vermeulen, 2004). Some authors have even gone so far as to suggest a unifying of approaches to innovation between the manufacturing and the service sector.

In Thomke’s study, Bank of America has applied the discipline of formal R&D processes to services. They have been running a series of formal experiments seeking to create new service concepts for retail banking. The company has turned a set of their branches into “laboratories” where research teams conduct live experiments during regular business hours. The results of these experiments are compared to those in normal branches, pinpointing attractive innovations for broader rollout. In this case, innovation in services, and services innovation is understood in broader terms, being extended to non-technological innovation.(Hipp, *et al.*, 2000).

3. Process of Innovation

In order to analyse innovation in a meaningful way, it is necessary to distinguish between the numerous stages, each of which have their own time-spans, resource requirements and decision approaches. There are several models in the literature suggesting the sequences of events in the evolution of an innovation (Wilson, 1966; Hage, *et al.*, 1970; Harvey, *et al.*, 1970; Zaltman, *et al.*, 1973; Kimberly, 1981; Rogers, 1983; Tidd, *et al.*, 1997; Van-de-Ven, *et al.*, 1999). As Edison realized, ‘innovation is more than simply coming up with a good idea; it is the process of growing them into practical use’ (Tidd, *et al.*, 1997). Rogers (Rogers, 2003), a leading researcher in innovation processes, proposed a model that consisted of a sequence of five stages (Table 1); the first two of which are concerned with the *initiation* and the latter three with the *implementation*.

Table 1: Roger's (2003) Stages of Innovation

Stage 1. Agenda setting	Initiation (Information Gathering)
Stage 2. Matching	
Adopt or Reject Decision	
Stage 3. Redefining/restructuring	Implementation and diffusion of innovation
Stage 4. Clarifying	
Stage 5. Routinizing	

The first two stages, 'agenda setting' and 'matching' represent the entire information gathering, conceptualizing, and planning effort leading to the adoption of an innovation. The decision to adopt or reject the innovation marks the end of the initiation phase of the model. The last three stages, 'redefining/ restructuring', 'clarifying' and 'routinizing' constitute all of the events, actions, and decisions involved in putting the innovation into use. Rogers does not consider his model to be fixed; the process may occasionally back-track or skip one ore more stages although he suggests "Later stages … cannot be undertaken until earlier stages have been settled, either explicitly or implicitly" (Rogers, 1983).

Field studies demonstrate the difficulties in analysing the process as a linear succession of events. Research led by Van de Ven involved fourteen in-depth case studies of technological innovations in a variety of fields including: industry; education; agriculture; health; and defense (Van-de-Ven, *et al.*, 1999). This study pursued a common theoretical background for the data analysis in the innovation process. Their results showed that ideas develop in different ways, moving from inventions to reinventions. Some ideas are discarded and others are carried one step forwards. In many cases different people are involved in the different stages, adding different perspectives and time horizons to the development of the idea.

At a certain level of abstraction it is possible to see the same basic process common to all of these models. The common elements in the innovation process are: 1) Initiation Period, 2) Development Period, and 3) Implementation / Termination period.

One key and unanswered question that arises from these models is whether the necessary factors for success are the same or different at each stage. More specifically, when looking at the situational context, is it possible to identify an optimal environment for every stage. The study described in this paper will measure the climate of the contributors and stakeholders reflected through the different stages of an innovation. This will enable the comparison between them and analyse what makes some stages "push" for an innovative environment while others hinder this attitude. So, people are to be considered the main actors within "the innovation journey"; they will be responsible for the success and development of the idea. How can we nurture a climate for innovation and creativity in a sector where often good ideas are not recognised?

4. Climate for Creativity

Climate plays a vital role in determining the outlook or likelihood of innovation, creativity, or change taking place in a particular place. The study will focus on the psychological aspects of the work environment commonly referred to as "organisational climate". Organisational climate refers to the recurring patterns of behaviour, attitudes and feelings that characterise the day-to-day life in the organisation as experienced and understood by the individuals. The climate is observable at a surface level within the organisation and it changes in a dynamic way. In this way, it is important to distinguish between organisational climate and culture. The culture refers to a long term characteristic with deeper and enduring values, norms and beliefs of the organisation. The culture is long standing, deeply rooted and usually hard to change.

In the context of the innovation process, organisational climate plays the part of an intervening variable which can affect the results and development of an idea (Figure 1). From our research we wanted to know about the prevailing climates in our case study organizations. From this, it was hoped that we could establish an association between certain climate factors and innovation success in FM.

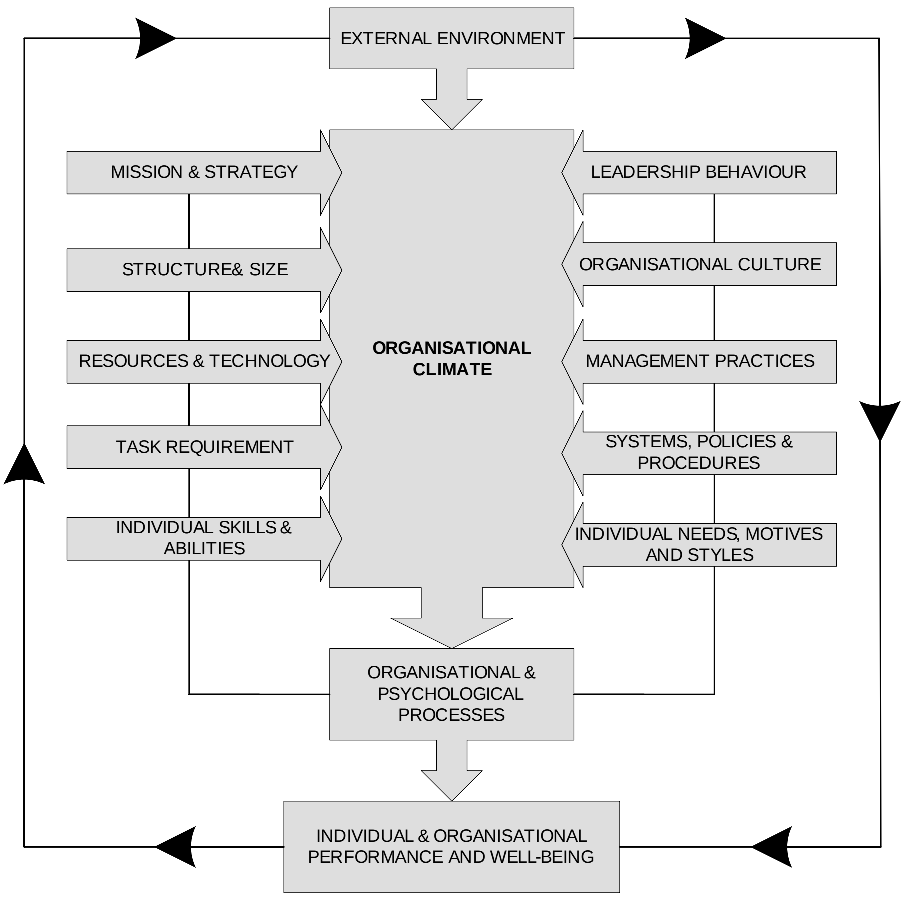

Figure 1 : A Model for Organisational Change (The Creative Problem Solving Group, 2002)

The organisational climate is influenced by many factors within and external to the organisation. The external factors refer to the markets changes, global financial conditions, and legislation that can affect the performance of the organisation. These factors cannot be controlled by the organisation; although it may demand new flexible behaviours within the organisation.

The transformational variables for organisational change are represented by the top four of the model shown above (Figure 1) – that is, ‘mission and strategy’; ‘leadership behaviour’; ‘structure and size’ and ‘organizational culture’. The mission and strategy define the basic purpose of the business and the way in which it is going to achieve it. Leadership behaviour includes any attitude seeking to transform the organisation. This has been found to have a profound influence on the perception people have of the climate for creativity and change (Ekvall, 1996). Organisational culture represents the roots that provide individuals with a sense of belonging to the organisation. It influences the way people respond to surprise, creativity and change. Structure refers to the way people and functions are arranged. Ekvall (Ekvall, 1996) has shown that the type of structure within departments of an organisation has an impact on employees perceptions of the climate in those departments.

The remaining elements of the model are referred to as transactional variables. They are used to preserve and implement changes taking place in the transformative level of the organisation. For the purposes of our research we applied this model using a standard measurement instrument known as the Situational Outlook Questionnaire.

5. The development of the Measure

The Situational Outlook Questionnaire has been developed looking at people’s perceptions of the character of life within a workplace. Its particular focus is on how attitudes, feelings and behaviours support creativity and change. This instrument grew from a research programme in Sweden during the 1980s concerning organisational conditions that stimulate or hamper creativity and innovation (Ekvall, 1996). The questionnaire tool was adopted by the University of Buffalo in the US from the earlier measure developed by Ekvall. As an Industrial psychologist working for Volvo in the 1950’s and other large Swedish companies in the 1960’s and 70’s Ekvall observed differences in how the working atmosphere of different companies affected the degree of participation in idea suggestions schemes.

The Situational Outlook Questionnaire (SOQ) will be used in this study to assess the climate for creativity, innovation and change within the FM sector. This tool enables a better understanding of the perception of the environment in which people work on a day-to-day basis and the impact on their predisposition for creativity and change.

The SOQ consists of fifty questions, with five questions for each of the ten dimensions. Each item is scored from zero to three; zero standing for "not at all applicable" and three for "applicable to a high degree." Thus, results will be reported in a 0 - 3.00 format.

The dimensions of the SOQ include:

- Challenge and Involvement: The emotional involvement of the members of the organisation in its operations and goals. A high challenge climate exists when the people are experiencing joy and meaningfulness in their job, and therefore, they invest much energy. Low challenge means feelings of alienation and indifference; the common sentiment and attitude are apathy and lack of interest for the job and the organization.
- Freedom: The independence in behaviour exerted by the people and tolerated within the organization. In a climate with much of this kind of freedom people are making contacts to give and receive information and discuss problems and alternatives; they plan and take initiatives of different kinds and make decisions. The opposite climate would include people who are passive, rule-fixed, and anxious to stay inside the frames and established boundaries.
- Trust/ Openness: The emotional safety in relationships. When there is a strong level of trust, everyone in the organization dares to put forward ideas and opinions. Initiatives can be taken without fear of reprisals and ridicule in the case of failure. The communication is open and straightforward. Where trust is missing, people are suspicious of each other and take initiative cautiously because of the high price mistakes bring.
- Idea Time: The amount of time people can use for elaborating new ideas. In the high idea time situation, the possibilities exist to discuss and test impulses and fresh suggestions that are not planned or included in the task assignment; and people tend to use these possibilities. In the reverse case, every minute is booked and specified. The time pressure makes thinking outside the instructions and planned routines impossible.
- Playfulness/ Humour: The spontaneity and ease that is displayed. A relaxed atmosphere with jokes and laughter characterizes the organisation that is high in this dimension. The opposite climate is characterized by gravity and seriousness.
- Conflict: The presence of personal and emotional tension in the organisation. When the level of conflict is high, groups and single individuals hate each other. There is gossip and slander present. In the opposite case, people behave in a more mature manner; they have psychological insight and control of their impulses.
- Idea Support: The ways in which new ideas are treated. In the supportive climate, ideas and suggestions are received in an attentive and kind way by managers and co-workers. People listen to each other and encourage initiatives. Possibilities for trying out new ideas are created. The atmosphere is constructive and positive. When idea support is low, the reflexive "no" is prevailing. Every suggestion is immediately refuted by counter-argument. Fault-finding and obstacle-raising are usual styles of responding to ideas.

- Debates: The occurrence of encounters and disagreements between viewpoints, ideas and differing experiences and knowledge. In the debating organisation, many voices are heard and people are keen on putting forward their ideas. Where debates are missing, people follow authoritarian patterns without question.
- Risk-taking: Tolerance of uncertainty and ambiguity evident in the workplace. In the high risk-taking case, decisions and actions are prompt and rapid opportunities are taken. In a risk-avoiding climate there is a cautious, hesitant mentality.

The nine dimensions and three supporting open questions in the questionnaire attempt to describe employee's perception of the atmosphere within the organisation, where higher scores on the nine positive dimensions with a lower score on the negative dimension (conflict) indicate a climate more conducive to creativity.

For FM professionals concerned with the design of the workplace, a surprising feature of the questionnaire is that there is no acknowledgement of the role of the physical environment on innovation. For example, an open plan design may encourage people to be more open about ideas. However, the tool has purposefully been designed with degrees of ambiguity to elicit a variety of views about what we mean regarding 'work environment'. Furthermore, the immediate goal of our research was to examine the broader concept of 'work environment'. However, we hope to develop our analysis in future studies to specifically address the role of the physical workplace in stimulating innovation.

The SOQ tool has been used for over 10 years in organizations around the world having studies (Ekvall, 1987; 1996; Ekvall *et al.*, 1983; Isaksen, *et al.*, 1999) supporting the validity and reliability of the SOQ. It is hoped that the results from the study can be used in a cross-comparison with other professions and other types of organizations drawn from this databank.

6. Methodology

The methodology used in this study measures individuals' perception of the climate dimensions for the three stages in the process of innovation: 1) Initiation Period, 2) Development Period, and 3) Implementation / Termination period. Respondents will complete the SOQ for each of the stages. As an accurate measure of the psychological climate for creativity the SOQ will be sensitive enough to show distinct differences between the three situations.

In this study the SOQ data will enable us to categorise organizations as being creatively innovative, average or stagnated. Since our study will also consider the stages of innovation, it is likely that organizations may exhibit different levels of innovativeness at different stages. In other words, the climate may be more supportive of innovation at the information gathering or implementation stages.

The SOQ is, however, not a direct measure of organizational stagnation or progressiveness. Rather, they act as a barometer gauging the general perception of how these dimensions are perceived within a given climate. The scores on the SOQ are best used as a profile and can help to identify strengths and potential weaknesses within any specific working situation.

The scores in the 'spider diagram' below give an example of the variation along the nine climates dimensions for a given organisation (Table 2). People in innovative companies exhibit higher scores for each dimension except for conflict.

Table 2: Comparison of Mean Scores for Three Types of Organisations

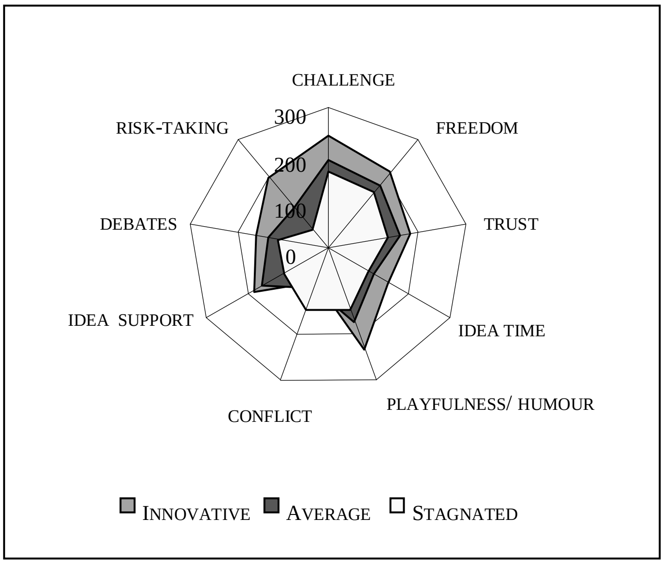

Table 3 Creativity in Stages of Innovation

	INITIATION	**DEVELOPMENT**	**IMPLEMENTATION**
Creatively Productive			
Creatively Average			
Creatively Stagnated			

From these results a comparison between the different stages of the innovation process will be undertaken (Table 3). This will help understand the psychological perception of individuals within an organisation (in this case the FM sector) during the "Innovation Journey", enabling the development of structures and systems to support organisational innovation in every stage of the process.

Being able to classify the stages of the process (creatively productive, average and stagnated), will benefit the organisation in various levels. On an individual level, the understanding of the climate will make the invisible more visible, prompting individuals to modify the climate within which they work. On a team level, an understanding of the climate will help promote honest communication among the team members. Suitable modification of the innovation climate will promote effective problem solving, enabling a productive group functioning and will shed light on unnoticed strengths upon which the team can build on. This analysis will allow organisations to better structure themselves to enable a more productive workplace; building upon those structures that seem to be working well whilst modifying others (Isaksen *et al.*, 1990).

7. Conclusions

This paper has provided an outline of the proposed study, identifying key unanswered questions for the facilities management community. The fact that FM is a service based industry has tended to marginalize the issue of innovation: a concept which has typically been exclusively associated with manufacture. However, the recent emergence of convincing research on *service innovation* is providing the imperative and analytical tools to further understand this process. The existence of an innovation network provides a unique opportunity to undertake longitudinal studies in innovation. The results from this research will enable the network not just to provide an exchange for good ideas but to acquire a more long-lasting understanding of how to 'do innovation'. From existing research, the evidence points to the fact that good ideas within a bad climate are inclined to fail and seemingly marginal innovations can have a big impact in supportive climates.

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Innovations and transfer processes in building management services. Organizational models, methodologies, procedures and tools

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Abstract

The developing market of building management services (e.g. property management or facility management) is now a day characterized by different complexity factors regarding both demand and offer operators. From this situation of complexity some problems arise in managing the services processes and in controlling and assuring quality. At the same time, till now it has not really been developed a specific culture for buildings services, made both of a methodological approach for organizational and operational functions, and of an appropriate system of tools.

On the basis of these considerations, the paper – after a synthetic investigation of complexity factors and their influences and problems on services organization – has the aim to point up a working hypothesis: innovations and improvements for building services can be developed through a process of transfer of methods and tools from different industrial and management fields with an appropriate adaptation to the specific context of building industry. The paper selects and analyses some approaches and their possible applications in buildings management services: first of all it deals with Supply Chain Management, defining different modalities of treatment of this approach inside different building services organization models (aggregation, integration, homogeneous system of services). Besides, about the supply chain management in building services, the paper deals with different actions inside services phases (design, planning, programming, monitoring and verification) and related process supports (procedures, resources and information management systems, tools, check-lists, key performance indicators, audit, etc.). Finally the paper analyses possible applications to building services of customer value approach and knowledge management systems.

Keywords: Buildings services, quality management, supply chain management, knowledge management.

1. The buildings services scenario

1.1 Growing market and complexity factors

In Italy the market of buildings services is constantly growing, as shown by some market analysis and statistical investigations (Table 1). This developing market is now a day characterized by different complexity factors regarding both demand and offer operators, such as:

- the increasing number of specific services regarding different operational areas that should be really integrated in order to pursue effectiveness and efficiency of processes;
- the multiplicity of interacting operators different for skills, know-how and methods due to their origin from different contexts and disciplines (industry, construction, logistic sectors, safety and health, security, economical and financial studies, etc.);
- the difference in organization and contractual models, with problems in defining roles, authorities and responsibilities;
- the large range of functions of buildings and real estate (e.g. residential, health care, industry, etc.), each one dealing with specific requirements for needed services;
- the large number of information regarding the buildings, coming from a multiplicity of sources, that have to be spread between different operators.

Table 1: Scenario of Facility management market in Italy (milions of Euro 2003). From Cresme, Facility management 2003, III Report Market in Italy, Proseg, 2003.

		Real demand					
	Potential demand	**2003**		**2008**		**2012**	
		Min.	**Max**	**Min.**	**Max**	**Min.**	**Max**
Industry	53.472	6.531	9.206	17.218	25.588	27.612	35.334
Retail	18.860	948	1.575	2.829	4.149	6.016	8.262
Hotel-restaurants	5.940	891	1.1.28	1.485	2.198	3.267	4.158
Transportations	7.090	1.1.34	1.347	2.482	3.687	3.889	4.963
Banks, Insurances	15.899	2.385	3.021	5.564	8,267	8.744	11.129
P.A., Schools, sanity,	33.966	5.435	6.793	11.548	19.360	20.379	25.474
Total	**135.227**	**17.324**	**23.070**	**41.126**	**63.249**	**69.917**	**89.320**

1.2 Organization models and services operators

Now a day the scenario of services offer is represented by a large variety of operators - different for dimensions, organizational structures and approaches, origins, financial resources, etc – all active in national – and often also international – market, both in competition and in association, in many possible configurations and in very dynamic manners.

It is possible to summarize as follows the more significant categories of offer operators:

- "great operators", for instance, operators coming from the industrial Global Service field, firms engaged in utilities management (production and distribution of gas, water, fuel, etc.), firms rising from industrial groups through "spin off", international firms operating in industrial maintenance and energy areas, real estate consultants, and so on. They are operators very skilled in organizational themes, with significant financial resources and with an easy access to banking establishment, that only now are beginning to deal with buildings characteristics and behaviours;
- construction firms that, inside a general scenario of transformations in construction market (fragmentation of organizations, increase of maintenance and refurbishment demand, new types of contracts, new regulations in public works, etc.), are looking for new business opportunities inside fields in which they can apply their technical knowledge about buildings, their capabilities of relationship with public administrations, their expertises in construction supplier management;
- specialized suppliers of services (such as energy management, cleaning, security, etc ,) that try to profit by their consolidated relationships with their Clients and by their capabilities in designing and managing services, in order to extend their business areas by adding new services;
- very small firms, traditionally occupied in technical works with operational expertises in buildings and equipments maintenance, that now are gathering together in networks in order to collaborate and to act as a "single entity" in service supplying. The aim is to answer in a very flexible and dynamic way to various market requests with different temporary aggregations of services, trying to be more and more adherent to clients requirements. The network may offer activities of design, coordination and control of the assemble of services.

In general the tendency is towards the assembly of many and different services, variable in its configuration, with a single interface for Clients. Clients are changing their tasks: in the past the main tasks were selection and coordination of all the different service suppliers, today the main tasks are the definition of global service requirements, the selection of an unique service provider, the control of service results. Notwithstanding such an evolution, at moment it seems that demand operators, even if quantitatively important, have difficulties in defining the services results in terms of quality requirements (WHAT), and are not still able to drive the ways in which the offer could better organize the services (WHO and HOW).

1.3 A working hypothesis: innovations and improvements through a process of transfer

Considering the actual, complex scenario, it appears that - even if many contributions, expertises, know-how are presents - the real potentialities of this field are not yet completely expressed, since it has not yet be developed a specific culture for buildings services, made both of a methodological approach for organizational and operational functions, and of an appropriate system of tools.

Following this reflection, a working hypothesis can be assumed: innovations and improvements for building services can be developed through a process of transfer of methods and tools from different industrial and management fields with a specific adaptation to the particular context of buildings industry. In particular, considering the above mentioned factors of complexity and the problems of coordination, the attention can be put on some basic aspects and approaches as, for instance: supply chain management, knowledge management, interactions between demand and offer operators.

2. Supply chain management in buildings management services

2.1 Supply chain management approach

"*Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouse, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system wide costs while satisfying service level requirements*" (Simchi-Levi, Kaminski, Simchi-Levi , 2000).

Considering this field of applications, through a process of transfer and adaptation from industry to buildings services, supply chain management can provide interesting contributions in terms of philosophy of approach, network management strategies, coordination modalities, methodologies and tools in the cases of many suppliers working together sharing some basic aims:

- to increase efficiency and effectiveness in complex services processes, where a high level of interactions exists between many decisions makers and operational teams belonging to different organizations, working with different modalities – sometimes synchronically, other times diachronically - on the same object (the building);
- to perform continuity and unique modalities in quality planning and control;
- to deliver a service constantly conform to customer requirements, reducing the period for response to not planned requests and to demand varying over time;
- to recognize and to solve, as soon as possible, possible conflicts between suppliers;
- to share common resources, information and knowledge with the aim of service optimisation.

2.2 Buildings services strategies according to supply chain management approach

Supply chain approach provides some keys useful to interpret actual and potential buildings services strategies. On this basis, at present it is possible to recognize different strategies in the processes and in the procedures that regulate the interaction between services suppliers. In particular, it is possible to identify at least three main strategies that represent different behaviours in supply chain management and that, at the same time, can be considered the steps of a progressive maturation of buildings services organizations, from a "simple addition" of services towards the creation of an organized system:

- *aggregation*. This strategy leads to some essential activities, such as selection of suppliers and control on results. Aggregation is typically the first step in multi-services organization and represent a very simple model of behaviour. It is based upon the definition of requirements for suppliers – and eventually of service delivery guide-lines - on the basis of the criterion coming from the objectives of the service, leaving full organizational and operational autonomy to the different suppliers;
- *integration*. This strategy has the aim to optimise the effectiveness of the processes and the quality of results through the coordination of the different suppliers, that preserve their internal own organization, but share with the supply chain interaction aspects concerning planning and development of activities, information, communication, logistic, etc. This strategy presupposes the individuation of an interface area inside the supply chain; from this area indications of coordination come and are spread to the suppliers that have to adapt their behaviours to needs "of superior order";
- *homogenizing*. This strategy represents the highest level in suppliers organization and the supply chain can be considered as an original entity. During the service period, the suppliers share not only coordination aspects connected with organizational and operational issues, but also: policies, strategies and goals expressed by the supply chain, collective service such as call centre, sophisticated management methodologies, information systems, purchasing

offices, legal and administrative supports, quality systems and procedures, safety and health management systems, statistical elaborations, data-bases, training and empowerment policies, and so on. Each supplier has to adapt the *modus operandi* to the supply chain directives, taking profit by using high quality services, that couldn't afford if standing alone, and by learning by high level experiences.

The acquisition of one of the different strategies implies that the activities of the supply chain management can cover a wide range of level (from the strategic through the tactical to the operational level), as synthesized in figure 1.

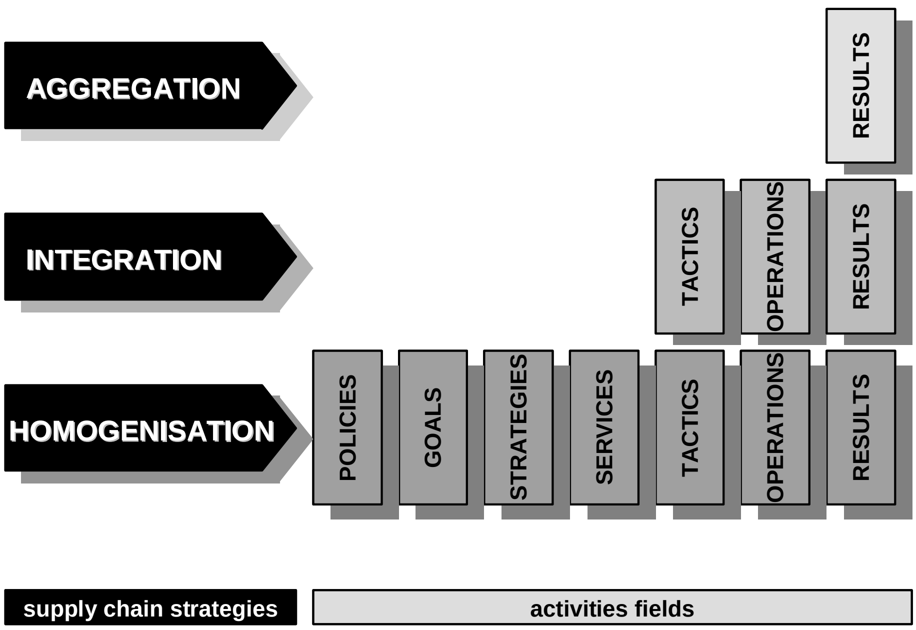
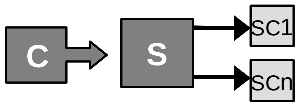
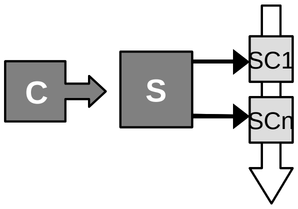
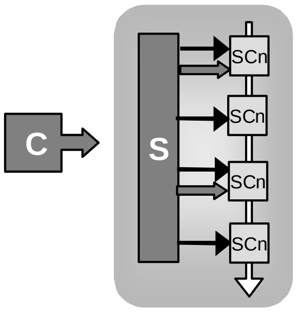
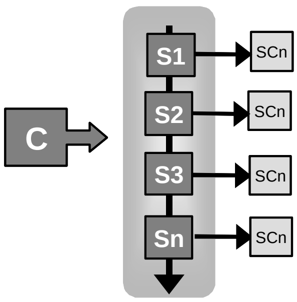
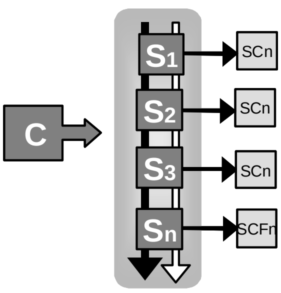


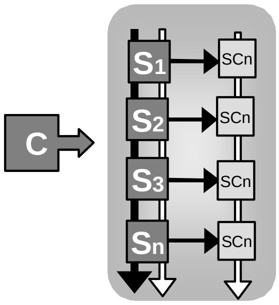
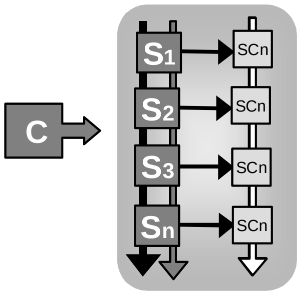
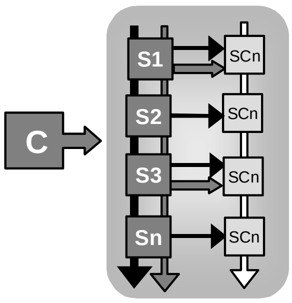
Figure 2: Supply chain strategies and activities fields shared by the services suppliers

2.3 Buildings services models according to supply chain management strategies

According to the above described supply chain strategies, it is possible to define several buildings services models (table 2), representatives of actual behaviours, of relationship with Clients and of modalities of interaction between suppliers.

Table 2: Schemes of the possible models concerning relationships between components of the supply chain

	Models	Description
MODEL 1		*Traditional model of one or several services in which the supplier is the only interlocutor of client. The supplier can select and aggregate sub contractors, that are chosen on the basis of prefixed requirements and controlled on the basis of the results that must be compliant to specifications and contracts.*
MODEL 2		*Evolution on model 1. In this case some aspects regarding coordination between sub-contractors are introduced. These aspects can initially concern operational actions and successively planning activities. It is possible to execute controls not only on final results, but also in process. Sub-contractors operate in autonomy, and may have to modify their plans only in the cases of necessary coordination with other sub-contractors.*
MODEL 3		*Evolution in the relationship Client-single supplier. Here it is the beginning of principles of supply chain management approach. The relationship between supplier and sub-contractors concerns not only the selection, coordination and control, but also involves goals, strategies, tactics. Inside the specific service contract, sub-contractors have to adapt some of their procedures and management methods (Quality systems, safety and health management, information systems, etc.). The links, that can rise, create the conditions for permanent relationships, also for other services contracts, toward the development of more advanced management styles.*
MODEL 4		*Model based on a relationship of the Client with a group of supplier, selected and gathered together in order to satisfy specific service requirements and to be more competitive due to the integration of many expertises and resources. Each supplier, for its competences, can interact with specific sub-contractors, according to the modalities of the previous models.*
MODEL 5		*Evolution of model 4. In this case there is a growing and a consolidation of relationships between suppliers, that are engaged in a permanent action of coordination in order to increase efficiency and effectiveness. This coordination can regard aspects related to planning, communication, information, logistic and criterion for selection and monitoring of sub-contractors.*

<table>
<tr><td>MODEL 6</td><td>
</td><td>The evolution of model 5 can lead to actions of extension of general coordination activities to the sub-contractors with effects of increasing efficiency of processes, better quality control actions, general sharing of knowledge and expertises to all the components of supply chain.</td></tr>
<tr><td>MODEL 7</td><td>
</td><td> Further level of growing of the supply chain management is the realization of an upper structure (the supply chain itself) that represents an entity that can be considered as a single decisional, informative and operational system, where all the suppliers share common policies, strategies, goals, procedure and services. The sharing of these aspect implies for all the supplier the acquisition of innovative management methodologies and tools. The expression of a common policy and goals allows to be much more competitive in the market and to better intercept and satisfy Client needs; besides it gives to the Client the guarantees of coherence and stability, very useful for fidelity and collaborations in relationships. Inside this model we can consider that the supply chain can be able to express an “intelligence of system” coming from the interaction between different shared expertises and knowledge of the suppliers, and that processes of auto-learning of the system are possible, amplifying, at level of supply chain, improvements realized at level of single suppliers. </td></tr>
<tr><td>MODEL 8</td><td>
</td><td>When the model 7 purses in maturation, it is possible to go to further improvements of the global system by involving in the sharing actions also some sub-contractors (for instance, the most significant for dimensions, for characteristics of their mission, for critic functions, for continuity in relationship, and so on).The homogeneous character of the supply chain is extended to lower levels, in order to increase knowledge and circulation of information and expertises, particularly those coming from operative fields. At the same time the sharing of management practices towards sub-contractors improves their competences and their capabilities of interaction with other component of the supply chain.</td></tr>
<tr><td>Key</td><td colspan="2">C Client   S Supplier   SC Sub-contractors   Supply chain
Selection   Coordination   Sharing</td></tr>
</table>

3. Supply chain management activities and supports

According to the eight proposed models for the supply chain management and on the basis of the key strategies of organization for buildings services (aggregation, integration and homogenisation), it is possible to analyse the different phases of service process (design, planning, delivery, monitoring and control), to underline the characterizing actions (selection, coordination, sharing), and to define main activities and related supports (table 3). In this paper only the most complete situation regarding homogenisation strategy is analysed.

Table 3: Key strategies of organization for buildings services according to supply chain management approach and, for each one, main actions characterising the different stages of a service process

		SERVICE PROCESS STAGES			
STRATEGIES	**ACTIONS**	**DESIGN**	**PLANNING**	**DELIVERY**	**MONITORING AND CONTROL**
aggregation	*selection*				
integration	*selection and coordination*				
homogenizing	*selection, coordination and sharing*				

3.1 Main activities and supports in service design stage according to homogenizing strategy

The main activities and related supports that characterize the design of service performances operating according to a homogenisation strategy regard:

- *design and implementation of the organizational structures*. The supports for this activity can be: organization chart (hierarchical and functional) of the structure; operational structures (call center, purchasing and legal and administrative offices, technical departments, EDP, etc); job description for main roles of the structure; information system;
- *definition of goals, policies, strategies and guide-lines for the management of the service.* The supports for this activity can be: management manuals (technical, administrative, logistic, health and safety, etc.); tools for Customer Relationship Management (CRM); management manual for quality; organizational and operational procedures (for coordination,

communication; interaction with Client, processes control; results control; management of environment, health and safety); procedures for purchasing (sub-contractors selection, structures of the orders, terms of payment, etc.);

- *statement of a knowledge management*. The necessary tools are knowledge management systems;
- *statement of benchmarking processes inside the supply chain.* The supports must be indexes for processes, results and client/customer satisfaction measurement;
- *human resources policies.* It is necessary to adopt training and empowerment procedures and programs;
- *definition of requirement for sub*-contractors selection. It is essential to rely on lists of organizational, economic, technical, logistic requirements. Typically: tools as vendor lists of sub-contractors of previous services and works, and procedures for the quality management of sub-contractors;
- *definition of strategies of customer value.* It ca be useful to collect and analyse previous clients relationships and to operate with case-based knowledge systems.

3.2 Main activities and supports in service planning stage according to homogenizing strategy

The main activities and supports that characterize the planning of service deal with:

- *briefing between suppliers*. The supports for this activity can be: general scheme of constrains, goals and service standards;
- *coordination of activities of documents and data collection and of physical survey*. It is necessary to adopt a common system of classification and coding for buildings and their parts;
- *implementation of the information system for the service*. It is necessary the assumption of an information system and the related procedures for implementation and use;
- *definition of the general plan for the service.* Supports can be: general scheme of the plan; guide-lines and criterion for the definition of priorities in the execution of interventions; guide-lines and criterion for logistic optimisations;
- *definition of the operational program for the service.* It can be useful to adopt methodologies such as linear and reticular programming techniques; besides it is necessary to point out target start and target completion (constraints in beginning and end of activities);
- *assumption of a common logistic support.* The main supports are: centralized purchasing office, a common warehouse management, a general qualified sub-contractors register;
- *implementation of common scheduling*. It is essential to get a centralized system of management (emission, allocation, closing, report) of the work orders;

- *training of workers.* Training activities ca be sustained by actions of tutoring (learning on the job), by procedures and instruction for the specific tasks and by teaching sessions based on themes closely connected with services jobs.

3.3 Main activities and supports in service delivery stage according to homogenizing strategy

If design and planning phases have been well conducted, if all coordination actions have been stated, and the flow of information, decisions and resources is adequately supported, in the development phase the main activities are merely:

- *management of resources*. The required supports can be: procedures and instructions for procurement and management of materials and services; information system with ERP functions (enterprise resources planning); procedures and instructions for warehouse management;
- *global vision and monitoring of current activities inside different suppliers services, with particular attention for safety aspects.* Useful supports can be coordination procedures for activities at high risk OHS (for instance Lock-out/tag-out, work permit, etc.);
- *work orders emission*. It is necessary to use an information system with functions for management of programmed and not programmed interventions;
- *report of completed works*. It is fundamental an information system with functions for implementation of clinical data sheets (feedback data);
- *continuous upgrading of information about building conditions*. It is necessary the presence of a system of technical, diagnostic and clinical data sheets.

3.4 Main activities and supports in service monitoring and control stage according to homogenizing strategy

It is very important to carry out activities regarding both monitoring and controls during services processes and at the moment of completion of works. The results of the services, the performances of suppliers and of sub-contractors that have been checked, fundamental interactions and communications with Client and between suppliers, and eventual problems, non conformity and corrective actions executed must be registered, analysed, elaborated, collected inside knowledge management systems in order to spread between the supply chain components new experiences and to increase the expertises of the chain.

The principal activities regarding monitoring and control functions are:

- *monitoring of sub-contractors performances*. It is useful to adopt: benchmarking indicators; *work-sheets* and *time-sheets;* procedures for supervision on works advancement and for account control; evaluation sheets for sub-contractors. It is important to record results of monitoring review inside information system;

- *monitoring of suppliers performances*. Possible supports are: process monitoring procedures; recurring audit sessions based on effectiveness indicators and in general on benchmarking indicators; *work-sheets* and *time-sheets;* procedures for supervision on works advancement and for cost accounting. It is important to record results of monitoring review inside information system;
- *monitoring of critical activities advancement* though specific work-sheets and time-sheets and specific monitoring procedures;
- *claim prevention on sub-contractors activities*. It can be useful to adopt special indicators, such as indexes regarding ratio between programmed and not programmed activities.
- *final control of suppliers services*. It is opportune to perform audit sessions based on client's satisfaction objectives. It is important to record results of audit review inside information system.

4. Conclusions

The evolution in building services market is now facing the need for an evolution of the traditional service delivery models. Both on demand side and on offer side the transition is towards the complete integration of different services; consequently the traditional model of service suppliers (mainly coming from the construction industry) needs new approaches in order manage the various complexity factors. The SCM "Supply Chain Management" approach seems to be particularly suitable and appropriate to give contributions for organizational and operational improvements in suppliers behaviours and, in general, for the maturation of an original culture in services field. It is therefore important that researchers and operators could join their efforts and interests about these themes also in order to smooth the progress of transfer and adaptation of principles, methods and tools from the industrial to the building sector.

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Challenging the 'Uniqueness' of FM Organisations in the UK

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Abstract

FM organisations have long been argued for their being unique entities, like fingerprints... And when relating these organisations to each other, analysts and researchers use market sector based classification systems as the only criteria to group them. This paper is the first series of two papers, and demonstrates that current practice of relating FM organisations to each other in comparative studies has led to unintended results since it overlooks many significant characteristics of the Facilities Management organisations. This paper examines methods used in classification of organisations in general and then suggests a classification system for facilities management organisations.

We suggest in this paper that classification as an end product enables to relate FM organisations to each other in order to understand the similarities and dissimilarities between them. The outcome aims to be useful for those involved in comparative studies in FM organisations.

Keywords: Classification, FM Organisations, Market Sector based Classification

Introduction

In organisational studies, authors [1,2,3,4] argue that unless there is an adequate classification system, there is little guide for both practitioners and academics in understanding the organisations. It is therefore inappropriate to explore if what works in one organisation will work in another, and relate them to each other since there is no basis for knowing if the organisations are of the same type [4].

Yet, there is no classification system for FM organisations. And if we give Bailey the benefit of the doubt, without a classification system and rationale, we risk developing advanced concepts, reasoning, discourse and data analysis for FM organisations.

Bev Nutt [5] stresses the lack of relevancy and relativity in FM field, and estimates that: *"Only 40% of good FM practice can really be relevant to everyone in the world."* Academic colleagues recognise the diversity and fragmentation in practice [6,7,8,9,10] and they attribute this diversity and fragmentation to the nature of ‘client organisation’ (henceforth referred as: context organisation) [11,12]. Operated within the context organisation [13], FM responds to specific problems [14,15] and fails to form universal or common conceptualisations. The response of FM to its clients therefore become contextual [16,17,18]. And relating FM organisations to each other hence is merely based on the definition and classification of context organisations, assuming that FM organisations operating in similar contexts behave similarly.

The fundamental of classification is to ascertain the key characteristics on which the classification is based. So the research question we adopted here is: *what are the fundamental characteristics (patterns) of Facilities Management organisations that make them similar or dissimilar*? This paper represents the characteristic variables of FM organisations, and suggest that when measured, they are enough to distinguish one from another.

This paper, at the onset, starts with the negative side effects of the current classification system in the UK, and compares it with both FM literature specifically and then organisational literature in general. It then proposes a framework of a system for classification of the FM organisation.

1.1 Current practice in classification of FM organisations

Relating one organisation to another is mostly practiced in comparative studies, where consultants or academics attempt to compare like with like to deliver to an objective. However, these studies have been heavily criticised because of them being shallow and dysfunctional for organisational needs [19,20].

To better analyse the rationale for the current practice in comparative studies, we conducted a series of ‘focused interviews’ with both consultants and clients who have previously involved in comparative research studies. We focused our query on the current classification rationale in FM, and asked respondents about the negative side effects of practice, and also their suggestions for developing better classification systems.

All of the interviewees agreed that the current classification rationale rooted in market sector based classification is pragmatic and cost efficient in nature e.g. Standard Industrial Classification (SIC).

The main advantage of classifying according to SIC is: one can explain organisations’ response to similar operating environment—such as market sector and its pressures; regulatory influences — and organisations’ exposure to those market pressures. However interviews also showed that taken SIC as *the only* matter of classification causes misinterpretation in analysing FM organisations. Interviewees highlighted the following negative side effects of this practice:

a) The current classification rationale only helps the weakest practice to become a standard practice.

b) If not go in-depth, can lead into wrong business decisions.

1.2 Classification in FM Literature

Becker [21] and Davis et al. [22]; Price [23] and Brochner [24]; and Williams [25 and Varcoe [26] have introduced three different sets of classification rationale for Facilities and FM organisations. The pioneers of the idea of classifying FM organisations were G. Davis and F. Becker [21, 22].

First, Davis and his team classified 18 context organisations according to nature of change (low change/high change) and the nature of work (routine/non-routine). To them, FM operates differently in different contexts because of the attempt to fit into the organisational change. Similarly Becker advocated that FM can be categorised according to the context organisation, and his FM typology is based on FM's response to its context.

Relations between FM and the organisational change, and FM organisation's response and responsibility to change became an area of research especially in the 1990s. Several authors [14, 15,21,27,28] emphasised the Facility or FM as a change mechanism to adapt the organisational resources like buildings, systems, processes for the changing conditions.

Secondly, Price [23] proposed a generic classification system that incorporates the relationships between the context organisation and its customers. He sustains Bitner's [29] servicescape[1] idea from her classical work and concludes that there are two dimensions in classifying facilities: complexity of the service provision and the speed of customer feedback. The speed of customer feedback is related to the visibility and the proximity of service delivery to the customers of the context organisation. Brochner [24] further suggests that the duration of service relationship as an indicator for classifying the 'settings'. He exemplifies the difference between a restaurant and a hotel setting, former being a short term interaction and latter a long term.

Thirdly, Williams [25] and Varcoe [26] took a procurement and service provider relations perspective in defining and characterising the patterns in FM organisations and the industry. Williams models Facilities Management organisations in the following categories:

I. Total in-house facilities management
II. Outsourcing as 'Single', 'Bundled' or 'Packaged' Contracts
III. Total facilities outsourcing: management contract
IV. Total facilities outsourcing: managing agent

In addition to these three sets of classification rationale, we added the fourth: personnel's expectations. The influence of personnel on the FM policies and practice are mentioned extensively

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[1] In 1992, Bitner defines servicescape as the built environment surrounding the service. However at a later publication in 2000 she feels the need to expand this definition to include social environment. Her recent definition of servicescape is: "immediate physical and social environments surrounding a service experience, transaction or event" (Bitner, M.J. (2000) The Servicescape in (eds) Teresa A. Swartz and Dawn Iacobucci, Handbook of Services Marketing and Management, Sage Publications, Inc., Thousand Oaks, p.37)

in the context of workplace making [30], staff involvement to workplace and FM decisions [27,31,15,21,32,33], usability. The involvement and the positive experience are usually to highlight the importance of managing the personnel's expectations. The better the expectations are managed, the better an FM organisation performs [24,35]. User involvement is primarily considered as means to manage their expectations.

However, these different approaches for managing personnel expectations have not been classified in FM literature. Although authors (those mentioned above) have attempted to classify FM organisations or their practices in their own area of study, there is still no holistic research encompassing these suggested characteristics variables in FM.

These different points of views in FM literature show also the diversity in FM perspectives. Notwithstanding Grimshaw's [10] criticism about the diversity of FM practice, it is also clear that: so does the theory...

1.3 Classification in Organisational Studies

Classification of organisations is not new to the academic fields of organisational behaviour. One could look at the use of Standard Industrial Category (SIC) Codes to see the utility of such classification systems. However, researchers over thirty years developed typologies based on a wider variety of criteria including: size, use of technology, strategies employed, systems utilized, degree of environmental stability, and who benefits. However none of these studies purposively addressed classification of organisations as the main topic. Instead, authors built up their research on these classes and prove or disprove their assumptions as the outcome of their research. It is therefore, of little use for the purposes of this research. However, authors agree on the scrutiny of *organisational structures* as the first step to describe organisations.

Organisational structure, as formal representation of an organisation, gives clues about people, influencing lines [36], decision makers, terminologies, duplicated work orders and tasks and integration and synergies [37,38,39], and even political conflicts [40,41].

2. External Patterns—Out: Relations between FM and its Environment

From both FM and organisational studies literature and the conducted interviews, we concluded that the relations an FM organisation creates are through (a) FM and its environment, and (b) FM and its formal and positional structure in an organisation. Attributes of different objects can be categorised in two groups: External patterns and internal patterns [42]. In other words, one of the relationships is related to internal structure of FM and another to its external environment.

External environment is where the transactions take place. This may include suppliers, clients or customers, and competitors. In addition, there will be more general aspects of the environment which will have important effects, such as legal, technological, cultural and ethical developments. The FM organisation and its external environment are explained here by four patterns: customers, personnel, organisational change and sourcing options.

In describing the significance of the transaction between an organisation and its environment, Pugh [43] states that (p.97):

“All organisations are situated in an environment, be that business, governmental, educational or voluntary service. In this environment are other organisations and peoples with whom transactions take place. These will include suppliers, clients or customers, and competitors. In addition, there will be more general aspects of the environment which will have important effects, such as legal, technological, cultural and ethical developments”.

Duncan [44] explains that characteristics of organisational environments are defined by the complexity and the dynamism. To compare, he illustrates that while banking industry operates in dynamic and complex, cardboard box industry operates in static and simple environment.

The external and internal patterns, or characterising variables used in this study are explained further below.

The context organisation is drawn like an amoeboid shape, representing the environment [45] in which FM organisation operates. The environment is defined as the source of inputs for the organisations and is the recipient of organisational outcomes [46.47]. We accepted context organisation as “the environment” for FM organisation.

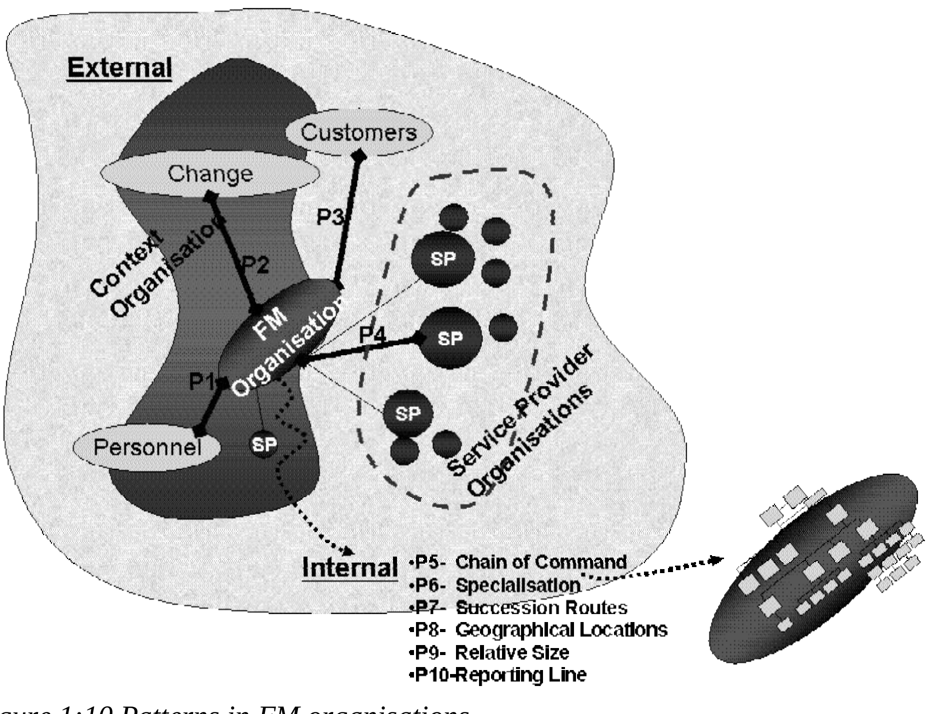

Figure 1:10 Patterns in FM organisations

<u>Proposition 1:</u> The external characteristics of FM organisations depend on its relations to the environment, more specifically to expectations of personnel, organisational change, visibility to customers and procurement options incorporating the service provider organisations.

Pattern 1 (P1): Occupancy profile

The quality of service delivery is driven by the personnel's expectations. Boyer [48] and Felder's [49] studies showed that there is a positive correlation between the occupational status and personnel's expectations from the company. However, this did not become apparent before Lee and Mitchell's study by the end of 1994. Their study discovered that professional background is the most critical parameter for managing the personnel's expectations in pursuit of employee retention [50,51,52].

In classifying the relationships between individuals and the employer organisation, Blau [53] and later Prandy [54] suggested nominal measures such as professional background (referred here as occupational profile) or occupational status as central to any sociological class scheme in organisations. They argue that "employee expectations change according to the professional background, which implies specific formal training and thus substantial homogeneity of background" [55].

This point was also stressed during the interviews. The interviewees stated that the level of quality in service delivery varies significantly according to the 'occupancy profile'. Some business departments are provided with better and higher quality services than the others. For example the building that accommodates CEO's office, is provided with a higher quality service than company's other buildings in its property portfolio.

This summarises the fact that unless the personnel's expectations are met, they might voluntarily leave the organisation, and therefore risk the company's performance [52,53,54].

More recent surveys by Office of Population Censuses and Surveys [55] classified employment and labour characteristics using the 'Standard Occupational Classification' (SOC), which consists of the following major groups:

I. Managers and Senior Officials
II. Professional Occupations
III. Associate Professional and Technical Occupations
IV. Administrative and Secretarial Occupations
V. Skilled Trades Occupations
VI. Personal Service Occupations
VII. Sales and Customer Service Occupations
VIII. Process, Plant and Machine Operatives
IX. Elementary Occupations

We used the SOC to identify the level of personnel expectations; i.e. the higher the rank in SOC, the higher the expectation. The distinction in rank also identifies the different patterns of expectations. To illustrate, out of the nine classes of SOC, the No.1, managers, executives are the professions with the highest expectations, and the occupations like elementary construction, agricultural, process plant occupations, come with the lowest expectations.

Pattern 2 (P2): Organisational change

Organisational change refers to forms of adapting the context organisation to its external environment and its requirements. Kaya and Williams' [57] previous study shows that there is a direct correlation between a company's churn rate and the speed of organisational change. Their findings substantiated Gladwin [58], Eley and Marmot [59] and FMA's [60] suggestions that the churn rate is an important indicator of change and dynamism in organisations.

However the churn rate should be monitored continuously. Gilleard and Yat-lung [19] criticise that comparative studies fail to address dynamic change by the use of static imperatives like churn rate. A snapshot assessment may give misleading results if the company goes to a business change during the period of evaluation. Kaya and Alexander [61] suggested some three to five years record of churn rate in referring to organisational change and its impact on the workplaces.

Pattern 3 (P3): Visibility to Customers[2]

Pattern 3 follows Price [23] and Brochner's [24] emphasis on the impact of physical setting and services (serviscapes) to customers' purchase intentions. We therefore suggest speed of customer feedback and duration of service relationship as two parameters for classifying facilities with respect to their visibility to customers.

The closer facilities services to the customers, the more visible they are, and therefore the faster the customer feedback. The longer the duration of service relationship, the more visible the services. In our analysis, we scored both the speed of feedback and the duration of services for the 22 surveyed organisations.

Pattern 4 (P4): Procurement Options

Pattern 4 follows Williams' [25] four types of procurement options as the indicator of structural relationships between FM and the service providers. We have earlier discussed that sourcing model and procurement options are the characteristics of the relationship between supply and demand.

The four external patterns dissolving relationships between FM and its environment, and the associated variables and attributes are summarised in the following table:

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[2] Customers are those the organisation is getting the benefit from. They are the raison d'etre for the organisation. The reader should be acknowledged that Drucker's (1954, p. 37), statement that the purpose of a firm was to create and keep customers – for "it is the customer who determines what a business is"

	Patterns	Variable	Independent Variables (IV)	Attributes
R1	Relations between FM and personnel Expectations of personnel from FM	Occupational status (Occupational profile)	See 9 categories above	Expectation score
R2	Relations between FM and organisational change	Workplace change	Churn Rate	% Percentage of the last 3 years
R3	Relations between FM and customers of context organisation	Visibility of FM services	Speed of customer feedback Duration of service relationship in the servicescape	Visibility Score
R4	Relations between FM and service providers	Procurement options	See 4 categories above	1-2-3-4

3. Internal Patterns—In: Formal Analysis of FM Organisations

FM organisations are no different than any other organisations. They have organisational structures, internal relationships and an organisational architecture. The formal representation of an organisation often takes the form of an organisational structure, where the relationships are represented.

Proposition 2: If FM organisations are not different than any other organisations, then organisational variables, such as hierarchy, specialisation, succession routes, geographical dispersion, size and reporting line should be the six internal patterns that define the formal analysis of an organisation.

These six dimensions are considered as the six patterns of an FM organisation with respect to its internal structure.

	Pattern	Variable	Independent Variables (IV)	Attribute
R5	Chain of Command	Organisational Structures	Hierarchy	# of levels between Head of FM and the Board member
R6	Specialisation	Organisational Structures	Span of Control	Max number of subordinates FM managers have management responsibilities
R7	Succession Routes	Organisational Structures	Reporting Director's span of control	# of positions represented for promotion to reporting director of FM. The higher the positions, the less succession opportunity
R8	Geographical Dispersion	Organisational Structures	Regions, states of countries FM has responsibilities	# of regions / states / countries
R9	Size	Size of FM Size of Context Organisation	Relative Size of FM	In-house FM staff per personnel
P10	Reporting Line	Organisational structures	The position or function to where FM is reporting to	1- Board 2- Property 3- HR 4- Operational Director 5- Finance Director

Pattern 5 (P5): Chain of Command

This refers to the unbroken line of authority that extends from the top of the organisation to the bottom. It can be measured by counting the number of levels in a typical organisational structure. It is one of the key characteristics to define and organisation. When people are talking about the hierarchy, tall structure, flat organisation they usually refer to gain of command in organisational structures.

In FM organisations the hierarchy can be measured by counting the number of lines that extends from the bottom of the FM up to the Board member.

Pattern 6 (P6): Specialisation

Child [62] emphasises that specialisation deals with the number of jobs broken down into narrow areas of work and responsibility so as to secure the benefits of specialisation. Specialisation is widely used in organisational analysis to refer to the dissemination of responsibilities according to the specific areas of expertise.

For the FM organisations surveyed in this Thesis, the focus is on the degree of specialisation; i.e how specialised are the FM organisations. This can be understood from the organisational charts by reading the maximum number of subordinates reporting to a direct line.

Pattern 7 (P7): Succession Routes under Reporting Line

It is a structural issue if the jobs and tasks should be grouped according to functions or product or service type. Succession route shows the ways of promoting vertically.

In FM organisations, the succession route is the flow in the organisational structure that leads into the reporting line. It is therefore if the Reporting Director's span of control is limited to three, then succession route is limited to three too because an FM emploee progressing his carreer in FM can be pushed upwards in the organisational ladder up to the reporting line.

Pattern 8 (P8): Geographical Dispersion

Organisations operating in different regions, countries locations also represent this geographical diversity in their management concerns. For example they represent regional managers dedicated for a specific region and structure the regional organisation accordingly. While in some cases this might give some autonomy, in some cases this is nothing but unnecessary fragmentation of business.

FM is no different to any other organisation, and in a diverse property portfolio it might structure itself in respect to the number of geographical locations that business operates.

Pattern 9 (P9): Relative Size

Size of the organisation [53,63,64,65] is one of the most important aspects of an organisation [66]. Blau [53] incorporated this relationship as one of the two major basic generalisations in his formal theory of organisations.

However, rather than referring to size of the FM organisation only, in this research we suggested to use 'relative size', since it reflects the weight of FM in the organisation. Relative size refers to size of FM and the context organisation. For instance, an FM organisation with 15 FM full time employees (FTE) responsible for 10,000 occupants is different than an FM organisation responsible for the same number of occupants with lesser FTE's. This is formulated as:

$$No = \frac{\textbf{Normalised} \left[\sum \textbf{personnel}\right]}{\textbf{Normalised} \left[\sum \textbf{FM employees}\right]}$$

This fraction is another attribute to understand what proportion of the population FM represents in the organisation (FM's catchment population).

These nine patterns suggested here are the characterising variables for FM organisations, each of which is associated with independent variables. When these patterns merge and come together, they can classify the organisations at a multi-dimensional space. This is explained further down.

Pattern 10 (P10): Reporting Line

Positional power in organisations plays a vital role in decision making. Although there are other kinds of power, the reporting line best represents the positional power amongst them. Relating the organisational literature to FM, authority and reporting line are both related to positional power; such that one step higher level of management to Head of FM is an indicator of decision authority in terms of positional power. This Thesis has only analysed the positional power as means to the reporting line of FM organisations.

To identify the patterns in reporting lines the author has asked the UK's six national service providers to list the variety in their client's reporting lines [67]. Five common reporting lines are identified in the UK, these are: Board, Property Director, HR Director, Operational Director and Finance Director

Depending on the reporting line, the policies, strategies and processes of FM organisation can change. It is therefore considered in this Thesis as another dimension that characterises the FM Organisations.

4. Conclusions

This paper demonstrated the characteristic variables, called here as patterns of FM organisations that make one client side FM organisation dissimilar or similar to another. These patterns differentiate the way in which the FM organisations are formed for their goal attainment.

Four of these patterns are related to the external environment of an FM organisation. These are expectations of personnel, organisational change, visibility to customers and procurement options. And six of them are related to the internal structure of an FM organisation. These are: chain of command, specialisation, succession routes, geographical dispersion, size and reporting line.

This paper prepares the background for further studies in classifying FM organisations to relate and understand them in relation to their similarities and dissimilarities. When the measures of these 10 patterns are close, it means that they are similar to each other. The successor for this paper is the illustration of this empirical study in an application to define and identify the FM organisations.

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Mapping distributed knowledge to assess quality of complex urban environments

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Abstract

Municipal institutions and social housing corporations struggle to establish a efficient joint facilities management processes within economically and socially fragile urban areas. The key problem is establishing common understandings of constrained social situations. Through a concrete example, we explain the role of representation devices in bringing together knowledge about, on the one hand, day-to-day, facilities management and on the other hand, public management stakes concerning social housing. We finally present a dashboard that facilitates organisations in their efforts to measure their collaborative capabilities in achieving facilities management excellence in constrained urban areas.

Keywords: quality assessment, cross-boundary collaboration, urban regeneration, New Public Management

1. Purpose of the paper

Optimizing Facilities Management (FM) in public housing estates depends on the capability to articulate two apparently contradictory trends.

- ***minimizing coordination costs*** *:* on the one hand, the search for leaner and more cost-effective asset management processes favour governance principles designed to instil more (explicit) knowledge into better-aligned processes. Sophisticated asset management devices are developed to standardize coordination routines between specialized activities and manage cross-boundary collaboration. These devices are focused on control through rules, procedures and asset measurement techniques such as dashboards, planning devices and budgeting tools.

- ***managing unstable organisational interdependencies between facilities management contributors:*** on the other hand, as facilities management and maintenance performance is more and more the result of the capability to react adaptively to new and unforeseen circumstances due to citizens' practices, political agenda shifts, facilities managers need to *work and learn together* to cope with uncertainties.

Our paper is about the way FM teams build capabilities enabling them to cope with these two trends. We point out the impact of *quality definition devices* (FM standards, classification systems about unexpected events, data-processing tools, information repositories...) on building capabilities to manage the way *different* and nevertheless *interdependent* FM contributors *work and learn together* in poor urban housing environments.

Through qualitative case studies about seven cities of a French Region, [1] we highlight two main aspects about the way these quality assessment devices contribute to ***create and share knowledge*** through mutual adjustments between public housing institutions, municipal service providers and local political authorities:

- In a first part or this paper, we describe how key stakeholders (State administration, local authorities, urban services providers, public housing institutions) develop new *capabilities to represent collectively* "hybrid" FM processes bundling together technical and social knowledge about low-income families practices in their housing and urban environment.

- In a second part, we outline a "dashboard" measuring the organizational capabilities required to control and facilitate collaboration between *different* and nevertheless *interdependent* facilities management contributors; the "dashboard" allow FM teams to position themselves with regard to key capabilities in managing functional interdependences while preserving their own requirements according to the each phase of the facilities management process.

2. The context: coping with uncertainty

We have focused our research on the way Facilities Managers set up organizational routines to handle every day problems resulting from the lack of coordination between different institutions accountable for urban services of social housing estates situated in deprived urban areas. [2]

Our approach is based on qualitative case studies about a public program aimed at developing "arms length management" initiatives ("*Gestion Urbaine de Proximité*"). We highlight recent transformations initiated by New Public Management aimed at achieving affordable housing for economically and socially fragile populations. French administration [3] deployed since the early 2000' a contractual framework in order to formalise "service level agreements" between key service providers within housing estates. Latest transformations initiated by this contractual approach are designed to optimize public aid allocation to poor urban areas.[4]

The contractual framework is supposed to both develop business-like quality standards and assess FM teams' capabilities to solve complex urban problems resulting from social practices

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[1] Région des Pays de la Loire : Nantes, Angers, Le Mans, Allonnes, Laval, La Roche sur Yon, Saint Nazaire, Chollet.

[2] ZUS :Zones Urbaines Sensibles.

[3] An initiative called *« Gestion Urbaine de Proximité »* focused on developing social cohesion through a larger program called *« Politique de la ville »*

[4] A major move in this direction was the allocation of 4 billion euros to a new government agency (*ANRU - Agence Nationale pour le Renouvellement Urbain*) in order to create a new offer of 250 000 social rental residences envisages, the rehabilitation of 400 000 social rental residences and the demolition of 250 000 residences before 2011.

of vulnerable households. These problems are frequently linked to the fact that decision making processes depend on collecting dispersed information about the quality of services delivered within large-scale housing estates.

Facilities management teams need to develop capabilities enabling a combination of on the one hand, technical *standards* optimization and on the other hand, social awareness of the *specific* problems related to the fragile situation of the population living in these neighbourhoods. Our first diagnosis revealed that FM Key Performance Indicators of social housing institutions are still specialized, sector specific and poorly interoperable

Social housing corporations are predominantly focused on economic data expressing the return on investment of their housing park (turn-over, rent collection and arrears, vacancy rates). [5] Local authorities have developed throughout the past thirty years, large amounts of studies and informal knowledge about urban social practices. Their data is focused on inequalities in housing: mix of population, unemployment rates, special needs of minority groups and safety & security issues.

2.1. "Aligning processes" does not necessarily mean "instilling co-responsibility"

Facilities management teams in large scale housing face two main uncertainties:

- design and manage a *programme* to progressively and systematically up-grade the rapidly aging multi-storey dwellings characterized by mass housing construction techniques of the 70' and 80' ;
- Cope with *unexpected* events (vandalism, incivilities, etc...) that rapidly jeopardize quality of services delivered and generate heated discussions and (potentially) violent interactions with tenants.

There are at least two ways to deal with with the lack of coherence between planning FM activities and integrating disruptive events resulting from social practices.

The first way is to focus on "alignment" and minimising co-ordination costs. The search for leaner and more cost-effective organisations favoured initiatives designed to develop a business-like culture in traditional facilities management processes. Managers set-up quality standards that should be deployed by FM teams through "compulsory" and "unavoidable" processes. Market-oriented measurement techniques such as benchmarking and budgeting tools are supposed to achieve considerable cost reduction.

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[5] Corporations are more and more aware about the need to manage more effectively data about tenants' complaints; a nationwide effort is being deployed in 2005 to systematically use "customer satisfaction surveys" in day to day management.

But, we observe that in complex urban environments, process alignment doesn't necessarily generate higher levels of satisfaction of poor households and security living in aging housing park.

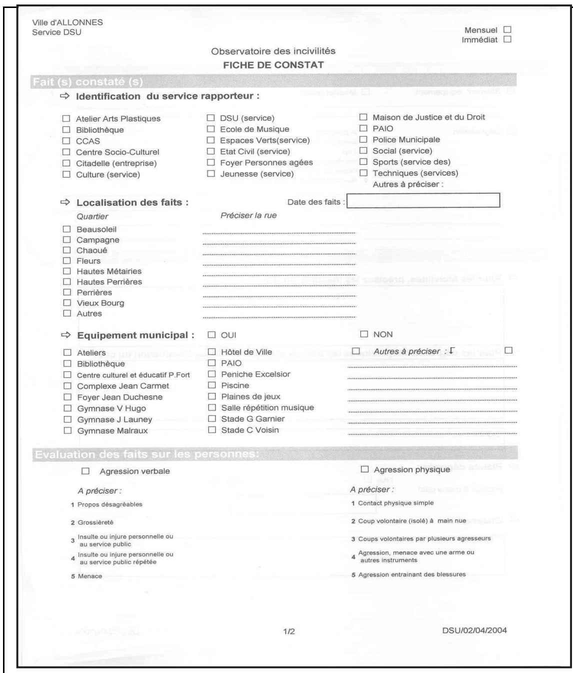
Approaches focused mostly on "control" reduces FM Team's capacity to cope with *unforeseen* events observed in the urban environment: *doing things by the book* within unquestionable and clearly defined structures diminished the more flexible forms of adjustments between social stakes and technical requirements.

An alternative way is to enable facilities managers to be able to deal with unforeseen events by enhancing the representation of every day (but nevertheless complex) problems.

Quality of services delivered within deprived urban areas, is considered as being a result of well-organized collaboration between different institutions. FM performance is based on the capability to work and learn *together*. Hereafter we describe an example of a simple device developed by local authorities of the city of Allonnes (France) to enhance their capabilities of dealing with numerous neighbourhood uncertainties encountered. The initial concern of the city council was the need to create a common means of representing problems faced by facilities managers and social workers during the summer months. During these holiday months, managers had less people at the "hot spots" of the neighbourhood where teenagers and young adults tended to carry out multiple forms of incivilities and degradation of urban equipment. The lack of resources acted as a spur to imagining alternative knowledge sharing, creation and re-use routines. To do this, municipal facilities management teams looked for a simple way to map unexpected events and improve follow-up procedures within the district. The resulting device was a two-fold representation characterised by two main components:

- a first page, sum up information about unexpected events,
- a second page, seize possible follow-up on curative measures and expected improvements.

The document was widely diffused in order to benefit from information supplied by "third parties".



Ville d'ALLONNES
Service DSU

Mensuel ☐
Immédiat ☐

Observatoire des incivilités
FICHE DE CONSTAT

Fait (s) constaté (s)

⇨ **Identification du service rapporteur :**

☐ Atelier Arts Plastiques
☐ Bibliothèque
☐ CCAS
☐ Centre Socio-Culturel
☐ Citadelle (entreprise)
☐ Culture (service)
☐ DSU (service)
☐ Ecole de Musique
☐ Espaces Verts(service)
☐ Etat Civil (service)
☐ Foyer Personnes agées
☐ Jeunesse (service)
☐ Maison de Justice et du Droit
☐ PAIO
☐ Police Municipale
☐ Social (service)
☐ Sports (service des)
☐ Techniques (services)
Autres à préciser :

⇨ **Localisation des faits :** Date des faits :

Quartier *Préciser la rue*

☐ Beausoleil
☐ Campagne
☐ Chaoué
☐ Fleurs
☐ Hautes Métairies
☐ Hautes Perrières
☐ Perrières
☐ Vieux Bourg
☐ Autres

⇨ **Equipement municipal :** ☐ OUI ☐ NON

☐ Ateliers
☐ Bibliothèque
☐ Centre culturel et éducatif P.Fort
☐ Complexe Jean Carmet
☐ Foyer Jean Duchesne
☐ Gymnase V Hugo
☐ Gymnase J Launey
☐ Gymnase Malraux
☐ Hôtel de Ville
☐ PAIO
☐ Peniche Excelsior
☐ Piscine
☐ Plaines de jeux
☐ Salle répétition musique
☐ Stade G Garnier
☐ Stade C Voisin
☐ *Autres à préciser :* ☐

Evaluation des faits sur les personnes:

☐ Agression verbale

A préciser :
1 Propos désagréables
2 Grossièreté
3 Insulte ou injure personnelle ou au service public
4 Insulte ou injure personnelle ou au service public répétée
5 Menace

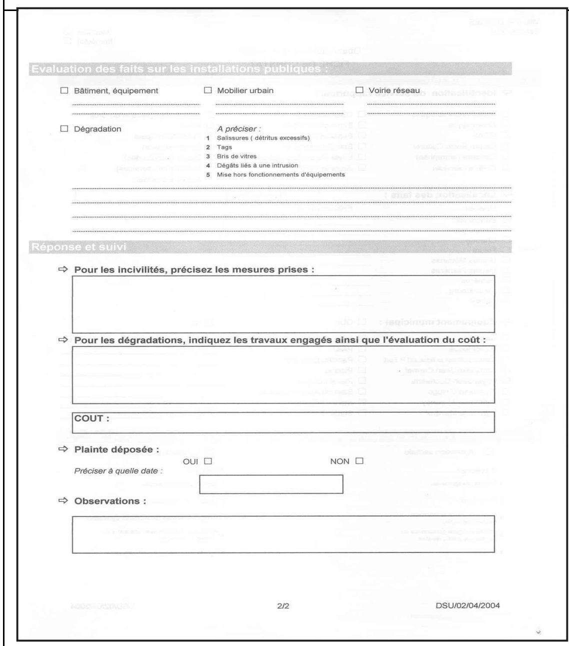
☐ Agression physique

A préciser :
1 Contact physique simple
2 Coup volontaire (isolé) à main nue
3 Coups volontaires par plusieurs agresseurs
4 Agression, menace avec une arme ou autres instruments
5 Agression entrainant des blessures

1/2 DSU/02/04/2004

The first page collects different forms of information to enhance the traceability:

- first step is the explicit identification of the institution that reported the event
- precisely identify who witnessed unexpected events,
- localize "hot spots"
- describe exactly the concerned urban equipment
- specify if there was verbal aggression and/or material deterioration



Evaluation des faits sur les installations publiques :

☐ Bâtiment, équipement ☐ Mobilier urbain ☐ Voirie réseau

☐ Dégradation

A préciser :
1 Salissures (détritus excessifs)
2 Tags
3 Bris de vitres
4 Dégâts liés à une intrusion
5 Mise hors fonctionnements d'équipements

Réponse et suivi

⇨ **Pour les incivilités, précisez les mesures prises :**

⇨ **Pour les dégradations, indiquez les travaux engagés ainsi que l'évaluation du coût :**

COUT :

⇨ **Plainte déposée :**
OUI ☐ NON ☐
Préciser à quelle date :

⇨ **Observations :**

2/2 DSU/02/04/2004

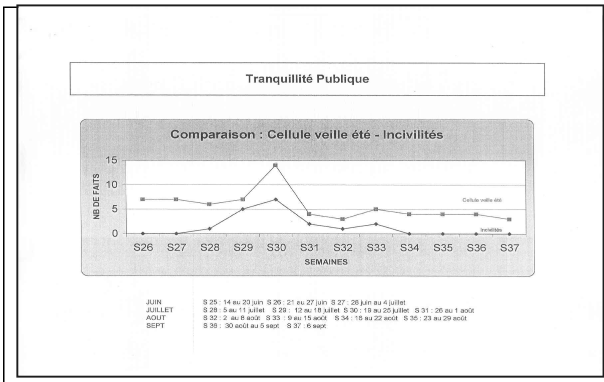
The second page, establish a link between factual information and the context where the event occurred by qualifying more precisely:

- *where ?* : dwelling and/or urban surroundings localization :
- *who* ? is accountable for curative actions? and *how ?* will follow-up be organized
- *how much* ? : costs and impact of curative actions undertaken; costs evaluation of repairs and follow-up on billing and insurances;
- *"and so what ?"* : traceability about potential legal pursuits (dates & qualitative observations).

This is an interesting example of an effort to "bundle" together information about non-programmed curative actions in order to produce a de-contextualized representation of the specific social practices of a district.

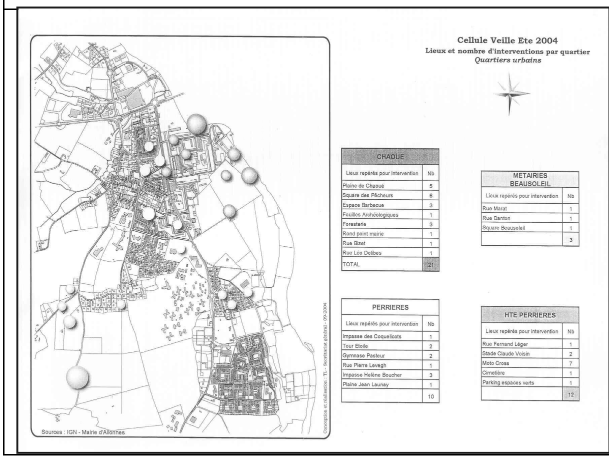
The detailed representation of the curatives actions in a district allows social housing managers and local government authorities to initiate the elaboration of a legitimate deliberation process incorporating both business-like criteria (optimization of facilities management processes) and welfare state ethical imperatives (improvements to obtain “affordable” quality of life in a poor district).

This approach enhances local team’s capabilities to represent coherently and publicly display *variations* of (unexpected) “vicinity problems”. We draw attention to this second step in the “*rhetorical”* [6] process which leads to a more legitimate representation of the “quality of life” in the district: formalising quality ***ratio variations*** is the basis of the rhetorical process leading to managerial ***accountability definition***. A simple data gathering device about day to day incivilities in the neighbourhood is the opportunity for qualifying responsibilities related to “exceptional” events in business-like facilities management processes.



Events are identified week by week. Seasonal peaks are identified so as that controversies [7] about accountability and resource allocation for proactive initiatives may be organized.

Therefore possible proactive initiatives may be organized in the following year to avoid this kind of disturbance.



Problems are also positioned in the urban space.

Simple software enables a clear identification of the frequency and the nature of the problems encountered by technical and social teams.

Priorities may be more *coherently* defined with regard to resource allocation.

[6] See also Laufer (2001) for a detailed explanation about the role of *rhetoric* and marketing techniques in legitimacy building processes of modern public management.
[7] Callon et.al. (2001), Latour (1987), Bowket and Star (1999).

LISTE DES SINISTRES

DATE	LIEU	NATURE DES DEGATS	MONTANT	REMBOURSEMENT	SOLDE
19-mars-04	ateliers municpaux	ordinateur, micro onde	6836,21	attente de la réponse de l'expert	
11-mars-04	Hôtel de ville	vitre	2137,4	1737,4	oui
02-mai-04	piscine	vitres	1190,03	790,03	oui
18-mai-04	stade garnier	armoire cassée vol maillots	980		
31-mai-04	piscine	porte	273,09	pas d'envoi franchise	
09-juin-04	complexe polyvalent	dégâts des eaux	non chiffré		
18-juin-04	podium couvert	lacerés cutter	251,16	pas assuré	
12-juil-04	complexe polyvalent	incendie, dégâts électrique	9387,64	passage de l'expert fait	
20-juin-04	gymnase J Launay	vitre	1227,3	827,3	oui
21-juin-04	ateliers municpaux	vitre	832,4	432,4	oui
13-juil-04	podium couvert	incendie	3 048,77	pas assuré	
15-juil-04	Ecole J Ferry	neon de cassé			
15-juil-04	ateliers municpaux	vitre, bombes de peinture			
16-juil-04	ateiers municipaux	vitre, vol de bombes peinture	406,31	sous franchise	
16-juil-04	matemelle Ferry	vol de vélo		attente inventaire de la directrice	
16-juil-04	ecole Massenet	accident sur jeux	1185,34	courrier à l'assurance	
26-juil-04	ateliers municipaux	vitre bombes de peinture	148,6		
06/09/2004	vitre mairie		371,88	sous franchise	
06/09/2004	vehicule s jeunesse	porte fracturée 9138WX 72			

A basis for a simple *benefits case* can be drawn from a spreadsheet adding up all costs related to a series of events in the neighbourhood.

Up-dating of budget programmes can be made and trade-offs may be discussed with local authorities.

In this case, more than just “aligning technical processes” and “coordinating team interventions”, local authorities designed a representation of the district practices that involved:

- articulating formal and informal knowledge sharing processes;
- combining individual skills to bundle together technical and social issues;
- capitalizing on unforeseen events to create knowledge enabling preventive actions in order to tackle constantly evolving social problems within these urban fringes of the city.

This representation of problems encountered during a specific period of time in the neighbourhood, creates pragmatic opportunities to establish “paths” between different forms of knowledge (individual-collective, tacit-explicit) where “exceptional” events are integrated into de-contextualised management procedures.

What seemed at first glance “exceptional” and unforeseen events (incivilities, destruction of urban equipment, etc.) caused by “deviant” youngsters gradually become an dimension of a “normal” facilities management process.

More *consistent programming* enables better co-ordination of curative actions which involve centralized municipal technical teams, local facilitators and social workers. Further detailed analysis of the data about apparently unsystematic events enabled pro-active initiatives to be implemented the following summer in the identified “hot spots” in the district.

Information transfer enabled by information repositories (light databases about recurrent incidents, technical documents about quality standards, Excell spreadsheets on curative actions costs, etc.) and light information and communication technology (e.mails, Intranet forums) counterbalance difficulties in frequently mobilising *all* the local teams involved in managing the district. Distributed co-ordination reduces the number of time-consuming face-to-face meetings.

3. A dashboard to assess FM capabilities building process

We highlighted the fact that mutual adjustments between public and private corporations, between technical experts, social workers and local authorities and – finally between the various institutional teams and citizens, are a key capability in deploying facilities management in constantly evolving neighbourhoods and unpredictable urban environments.

FM performance is a matter of building *capabilities to cope with uncertainty* rather then just setting an identified performance targets or service level agreements. The combination of different forms of knowledge creates a representation of FM processes that allows social housing managers and local government authorities to collaborate more effectively and securely share information about both the dwelling (internally) and the urban environment (externally).

FM teams are confronted to at least three key questions:

- *Firstly,* how to transfer information between different organisations, different sites, different teams?
- *Secondly,* how to integrate information about unexpected events into programmed facilities management processes?
- *Thirdly,* how to create the appropriate context that enables and encourages knowledge sharing and creation about potential facilities management improvements?

Our analysis shows that FM teams – in both public councils and private housing organizations - have difficulties in bringing together these three sets of questions. Working with a small team of FM project managers working in the seven cities involved in our research, we established a "road map" on which teams are able to situate themselves and rank their capabilities to address these key questions.

We describe hereafter these three domains of potential improvements in more detail and outline the progressive development levels of the corresponding capabilities.

3.1. Understand why unexpected events occur

Let us turn to the first set of questions. The introduction of a contractual definition of "service level agreements" of the service provided by different organisations [8] cause a lot of problems concerning the way *informal knowledge* is framed.

Teams need to develop their capabilities in prompting a new framing of unexpected events. This means being able to choose the right *questions* that trigger existing FM routines. It is more than just defining the content and the associated processes to codify and transfer "facilities management" data. It is rather choosing the right *problems* to be addressed in order to develop

[8] Public, semi-public and private organisations.

shared perspective about "doing" things together in the district. This requires a new approach and management skills focused on emergent information about the districts life, tenants' practices and their cultural specificities. The stages of evolution of capabilities related to representing functional interdependence are characterised in Table 1 below:

Table 1 – Framing functional interdependences

CONTROL	Top down approach focused on aligning FM "solutions" Functional interdependence as a "moral" injunction*: "teams must work together!"* No shared perspectives of the practical outcomes of the proposed enhancement of functional interdependence
FACILITATE	Identify knowledge "brokers" in charge of developing methodologies for identifying FM "problems" Quality assessment of user's needs done by technical experts
LISTEN	Aware of the need to involve users' communities Involve citizens to boost local initiatives and capture informal knowledge Develop FM skills to manage knowledge networking to analyse local populations practices in the neighbourhood
ASSESS	Development of a facilities management KPIs integrating informal "third parties" knowledge Link formal (budgetary) facilities management indicators and day to day quality of urban services (periodical surveys, …)
INTEGRATE	Assessment devices and survey results are integrated into the facilities management strategy Integration of short term facilities management indicators into budgets Communication on proactive FM initiatives to key stake holders (local authorities, elected officials)

3.2 Representing collectively functional interdependences through quality standards

A second type of capability concerns the way teams use the *As-is* diagnosis: how they create a shared view about current problems to enhance accountability definition. The importance of this type of capability is usually underestimated. When confronted to unexpected problems, FM managers jump immediately into curative actions guided by abstract *To-be* targets. These are usually defined by central experts and engineering oriented departments. In this case controversies are focused on FM "solutions". Each contributor to the FM process seeks to justify its variations of performance by pointing to problems caused by inconsistencies in services delivered by their counterparts. Creating a thorough diagnostic about the "problems" encountered facilitate teams to avoid controversies about conflicting "solutions." [9] Progress within this area is signalled by different stages shown in Table 2 below:

[9] An efficient way to establish this kind of organizational diagnostics is to walk around the neighbourhood to build collectively a shared picture of the situation. See. Allen and Bonetti (2004).

Table 2 – Representing functional interdependence

PASSIVE	Waiting to be confronted to unexpected events Random knowledge gathering about disruption in FM processes No systematic traceability about crises, incivilities, tags, etc.
AWARE	Aware of the need to involve key knowledge providers about potential problems in the neighbourhood Growing awareness of the importance of knowledge *re-use* for operational effectiveness (sharing lists of problems already solved)
ACTIVE	Involve "third parties" in "on the spot" diagnostics (local teams dealing day to day with neighbourhoods problems, technical experts) to clarify functional interdependence
OPTIMISE	Organise knowledge sources & implement a knowledge re-use strategy of existing dispersed k-bases Selecting best knowledge sources about unforeseen events based on various FM contributors
VALUE	Audit of knowledge re-use practice Measurement of "costs vs. benefits" of acquisition of new FM knowledge Action plan to map and manage overlaps in knowledge utilisation

3.3. Capabilities to communicate about FM performance

In order to diffuse efficiently ***To-be*** performance targets, FM teams need to go beyond the usual strategy consisting in defining a formal "quality charter" and communicating it through "top-down" initiatives. FM teams need therefore to address simultaneously two different initiatives:

- create more or less informal routines to share knowledge through day-to-day encounters to refine their ***As-is*** diagnosis about how unpredictable events disturb FM processes.
- establish stable ***To-be*** references and facilitate re-use of known information about current dysfunctions;

Confrontation about As-is "problems" and To-be "standards" creates the capabilities in going beyond the definition of de-contextualised "quality charters". The confrontations enable a more reliable *representation of performance variations*. As communication about expected performance targets becomes more en more effective teams are able to define and deploy pro-active initiatives. We have identified below a number of intermediate stages towards "best practices" in this area.

Table 3 – Capabilities to communicate about quality standards

PUSH	Use a push strategy for sharing knowledge through diffusion of "FM charters"
SELECT	Being aware of re-usability of documents produced to up-grade FM charter
INDEX	Define standardised guidelines for enhancing charters on quality standards Indexing documents for easy retrieval
CLIENT-FOCUS	Segmentation of user's needs Explain "how to use" the charter and/or related documents (tutorials) Add links to the document to point to the context (knowledge and people) / Best practices market (reward asset contributors)
DEMAND-DRIVEN	Diffuse charters and related documents only in response to an identified need Follow-up the re-use of diffused documents Put a value on key knowledge (metrics of use)

3.4. Organizing the representation of performance variations to secure information sharing

The third key area of action concerns the creation of the *context* to enable and encourage knowledge sharing and creation about FM performances. Designing such a context means developing a dialogue that can articulate both informal collaboration and formalized coordination. Here, organisational structures and physical conditions are important but not decisive.

What really "makes the difference" is the capability to set up links between day-to-day informal problem-solving and formalised co-ordination processes, "road-maps" between creative and fuzzy approaches to FM problems and practical outcomes with clear rules and formalised KPIs. These links can be established through a common set of diagnostics about the limits of current facilities management practices. [10] Organising "conversations" about key events [11], creating meaningful stories, building common languages and vocabularies are different ways to create a context that enables shared perspectives about "managing" knowledge. They also facilitate involvement of key actors in knowledge management initiatives.

Again, it is worth tracking the progress along the *formalisation* and *networking* paths separately, as the indications (shown in the Tables 4 and 5 below) are different:

[10] See Bonetti (2001)
[11] Carlile (2002)

Table 4 – Formalizing hybrid representations

NON-COORDINATED	Looking for FM tools to support formalised knowledge exchange Growing awareness of a limit of the informal management of knowledge
K-BASE	Attempt to gather the knowledge into knowledge bases Managing knowledge cycle through knowledge bases
K-BRICKS	"LEGO" approach to FM knowledge formalisation (best practices, references, methodologies…) Define categories of "LEGO" blocks to improve FM performance variations visibility
LINKS	Take into account the fuzziness of organizational knowledge Try to integrate experience and districts context with knowledge bricks
COMBINE	Organising "conversations" combining FM knowledge objects with face to face relationships & invest in organisational context

Table 5 - Networking

LOCAL	Informal knowledge is not structured in the neighbourhood Awareness of FM networks' fragility
BUILD	Awareness of manageability of FM networks Identify key collaborations around FM processes in the neighbourhood Managing organised links between informal networks
CONNECT	Enable knowledge re-use by communities of practices Organise face to face events about exemplary *"unexpected* problems solving *routines*"
WEB-BASED	Improving efficiency of knowledge transfer / re-use with ICTs Assessing FM contributors re-use practices Multiply connections through IT tools
INTERNALISE	Leadership's appropriation of FM management and involvement of local elected authorities in steering teams Hybrid representation of FM processes diffuse through all the layers of the accountable organisations

4. Conclusion: re-instilling uncertainties of "real life" through "hybrid" representations of FM processes

Our analysis of current practices within seven French cities of the Pays de la Loire region shows that FM teams working within social housing in deprived urban areas are facing the following paradox:

- the more public administration develop quality control devices to better manage technical and organizational risks due to constantly evolving poor neighbourhoods;
- the less local facilities managers are capable to deal with cross-organisational stakes and be involved in more unpredictable urban participatory policies.

To manage this paradox, teams are developing "hybrid" management tools to facilitate the articulations of different forms of knowledge about delivering urban services and taking into account the specific expectations of vulnerable households. Our findings show that the lack of shared quality assessment devices erodes the ability of facilities management teams to undertake FM initiatives in more "deliberative" agendas of urban planning and facilities management.

Research results highlight facilities managers' efforts to *introduce more flexible workflows* for until now relatively low coordinated practices based on shared diagnostics about problems. Most managers, especially elected local authorities, tend to underestimate that agreeing on the "problem" is frequently more effective than having the optimum solution. The key difficulty is to bring all institutions accountable for the quality of services delivered throughout the neighbourhood to establish and share a new balance between technical solution and social problems. Quality assessment infrastructures play a key role – they bring together apparently different types of knowledge (social & technical). They help to design the "facilities management lifecycle" ***across*** organizational boundaries. The *"hybrid"* [12] and *"abbreviated"* [13] representations of quality of services would consequently facilitate collaboration across public and private institutions. Through these representations they *publicly display* their complementarities within new deliberative forums.

Finally, the capabilities building "dashboard" is a simple – "work in progress" type - device to bring FM teams to assess their present position in building governance capabilities to enhance facilities management of social housing estates exposed to unpredictable events within vulnerable urban environments.

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Facilities Management Studies in Lithuania

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Abstract

Construction project management is a new and effective activity in Lithuania. The demand for construction project managers is constantly increasing due to the higher amount of constructions that increased in our country within the last years by 20-30 per cent per year. Contracting authorities of construction projects give necessary investments for the implementation of their ideas; they wish an optimal achievement of the goal with no deeper consideration of the implementation process of the whole project. This concerns all the stages of construction project management. Facilities management is one of the least investigated stages of construction project management in Lithuania.

In Lithuania, the term *facilities management (FM)* originated in the scientific and practical activity not long ago. Each country has different level and scope of the development of facilities management activities. Therefore currently, the determination of the efficiency of FM activities under the conditions of Lithuania is a topical issue that requires the proper evaluation of current situation, determination of the best practical models and scientific tasks as well as consideration of the recommendations that would contribute to the development process of FM activities in Lithuania. The preparation of different specialists of this field in universities and other education institutions is particularly of great importance.

Keywords: construction project management, facilities management

1. Introduction

Under the conditions of market economy, all contracting authorities of constructions are to follow strict requirements assessing the costs, quality and duration of construction works. To satisfy the requirements becomes more and more complicated, because all the processes of work have a tendency to become more complex and the scope of specialization is constantly expanding. Contracting authorities of construction projects wish the optimal implementation of their ideas with no deeper consideration of the implementation of the whole process. They are ready to give all necessary investments for this. Such conditions determined the origin of a new field of activities – construction project management. This activity originated in Western Europe more than 30 years ago and currently is becoming more and more important.

Project management is the integration of management functions, management methodology and management technique in order to achieve the desirable final results of project implementation. In special literature resources the term construction project management appeared not long ago therefore there is no exact and standardized definition of this concept yet [5].

On the basis of the experience of foreign countries, in Lithuania the process of construction project implementation is divided into several stages (Fig. 1). In the stage of the determination of expedience of a construction project the goals, tasks, restrictions and possible implementation variants of the project are considered. According the common standards or analogs, the financial analysis evaluates the costs of a construction project depending on the variants of selected construction sites. The goal of such calculations is to evaluate investment demand and financing possibilities.

In the pre-design stage the legal issues of project implementation are analyzed (i.e., whether it is purposeful to purchase the land or better to lease it) and the conditions to obtain the construction permit are discussed. In this stage principal technical solutions are analyzed, optimal project variants are selected, estimation for construction costs according to common indices is presented and the duration of construction works is determined [5, 6, 7, 8].

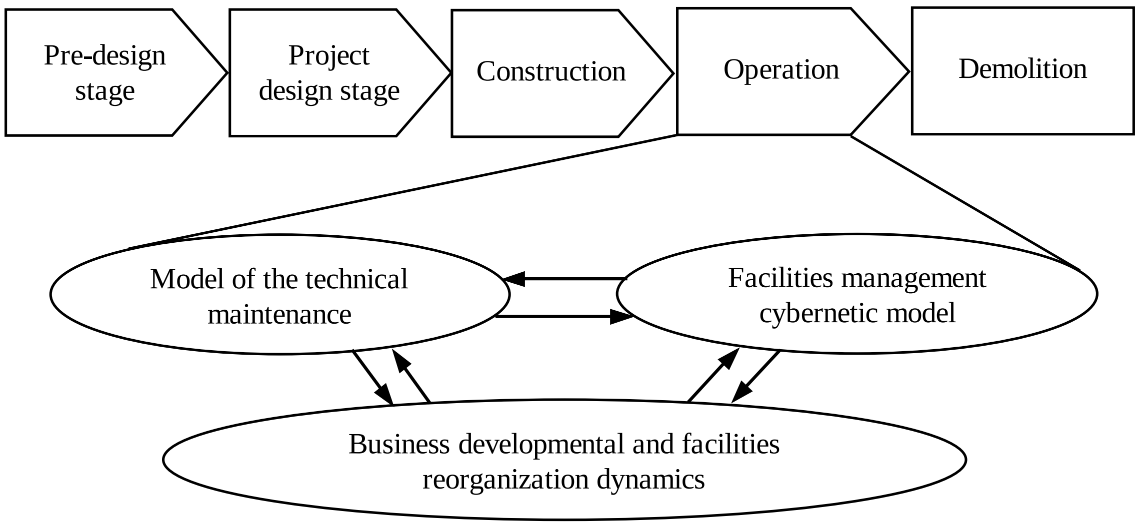

Figure 1: Constructions lifetime cycle and FM structural elements

During the project design stage the technical project of a construction is prepared. This part of the project includes a more detailed estimate. Having prepared the technical project and the estimate, a competition for the implementation of construction works is organized. The contractor-the winner is responsible for the engineering preparation of construction works, preparation of the implementation project of construction works and the implementation of construction works.

Before the operation of a building possible construction defects are eliminated. Then the building is ready to be used.

During the operation period of buildings different changes might occur that affect their operation qualities. Some changes may adversely affect comfort, domestic, work or industrial conditions; others may induce the disintegration of separate constructions or the whole building. This is due to the physical and moral depreciations of buildings. Physically depreciated buildings are often repaired: different elements are renovated, reinforced or replaced. Morally old buildings and the buildings with changed functions are reconstructed [15].

The maintenance and improvement of the functions of constructions within their lifetime require a purposeful implementation of strategic long-term organizational and economical tasks. Such activity is called facilities management [2].

Constructions used for different purposes have different constructional scheme, engineering equipment, main business technology, work regime and conditions (e.g., the activities of hospitals, gas stations, schools, etc.). Therefore the facilities management of different buildings has its individual peculiarities [14]. However, from the methodological point of view, common principles of FM activity are available [9, 10].

2. Problems and Tasks of Facilities Management in Lithuania

The term construction project management appeared in scientific and practical terminology in Lithuania about 10 years ago. The term facilities management started to be used about 5 years ago, because since then the construction project was understood and analyzed only until the onset of the operation period of a building.

The term facilities management comprises the object, its structure, operation functions and the whole operation system [11, 13]. Scientists of Lithuania and other countries give the following suggestion for the analysis of the facilities management: the problem is to be analyzed in administrative, technical, spatial (accommodation) and other services management aspects [16].

The effective activity of facilities management allows creating optimal conditions for the implementation of the main activities, the rational maintenance, repairing and modernization works of buildings; it also allows reducing operational costs of buildings as well as using efficiently the investments to ensure the modernization and necessary functionality of buildings [1, 4, 13].

In Lithuania, the maintenance of constructions is carried out in two ways: 1) the enterprise or owners of the building carry out all works by their potency or 2) facilities management services are provided by another enterprise according to the contract. Most enterprises and organizations in Lithuania carry out the maintenance of constructions by their own potential. Common industrial or added costs are used for this purpose, which makes up the greatest part of total expenses and adversely affect the competitiveness of the main activity of the enterprise. Construction maintenance departments are functioning inefficiently in the enterprise therefore this leads to higher expenses, compared to the costs needed for specialized construction maintenance enterprises.

Moreover, the quality of services is often insufficient as all works are usually done in the method of "fire fight". This means that defects are eliminated too late, i.e. only when they appear, and this requires much higher expenses.

To summarize the scientific researches and practice of constructions maintenance in Lithuania, facilities management problems and tasks might be divided into several groups (Fig. 2).

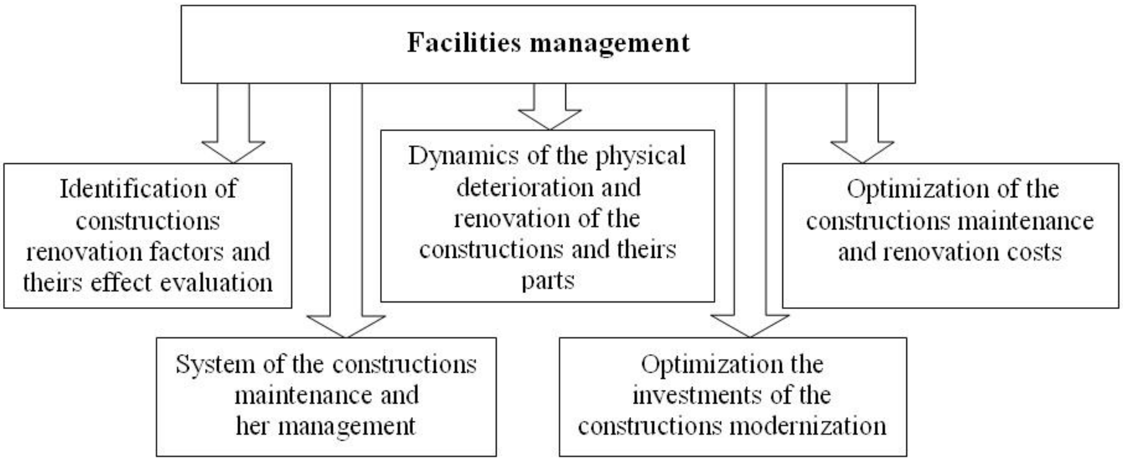

Figure 2: Tasks of facilities management scientific researches in Lithuania

In each group of tasks some studies have already been conducted. Lithuanian scientists have proposed the new multi-criteria evaluation method of the renovation of constructions and their separate elements. This method is based on the calculation of the effectiveness of a project or its components on common complex criterion evaluating the most important indices of the studied object. Moreover, the application of special software enables to create alternative solutions and to estimate them [16, 17, 18].

Scientific literature gives different reasons that determine the renovation of constructions. The reasons for the renovation of constructions in Lithuania are shown in Fig. 3.

Fig. 3 presents the results of scientific researches carried out on the determination of constructions renovation reasons in Lithuania. The results of those studies are needed for the prognosis of economy indices of constructions. The data of such kind of studies is different in each country. This is mainly influenced by the economical situation, traditions, legal environment, construction type and other conditions in every separate country.

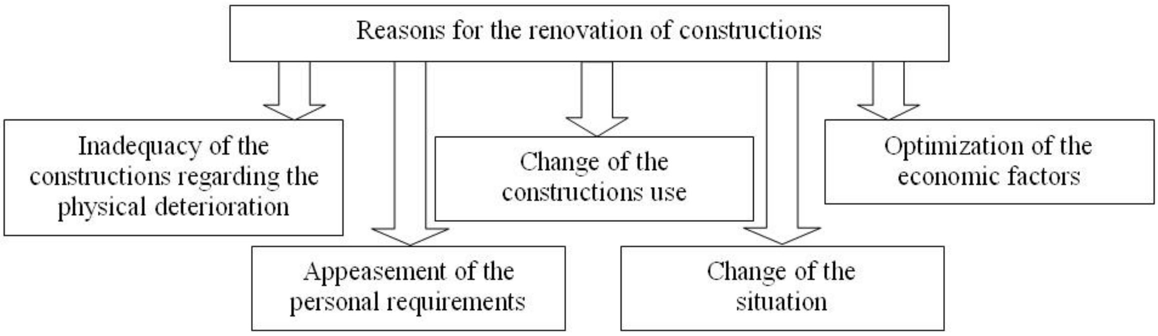

Figure 3: Possible reasons for the renovation of constructions in Lithuania

The dynamics of physical deterioration and reparation of constructions and their components makes the strongest impact on facilities management work structure the amount of necessary costs. During the construction operation period those costs and investments make up to 75% of total expenses during the construction lifetime period [3]. The amount of the costs depends on the solutions of a construction project and the effectiveness of facilities management activity during the construction operation time (Fig. 3). Having analyzed the dynamics of physical deterioration and reparation of constructions and their components, an optimal facilities management functioning model can be created.

The model of construction maintenance and reconstruction allows optimizing the amount of necessary costs and demand of investments during the construction operation period.

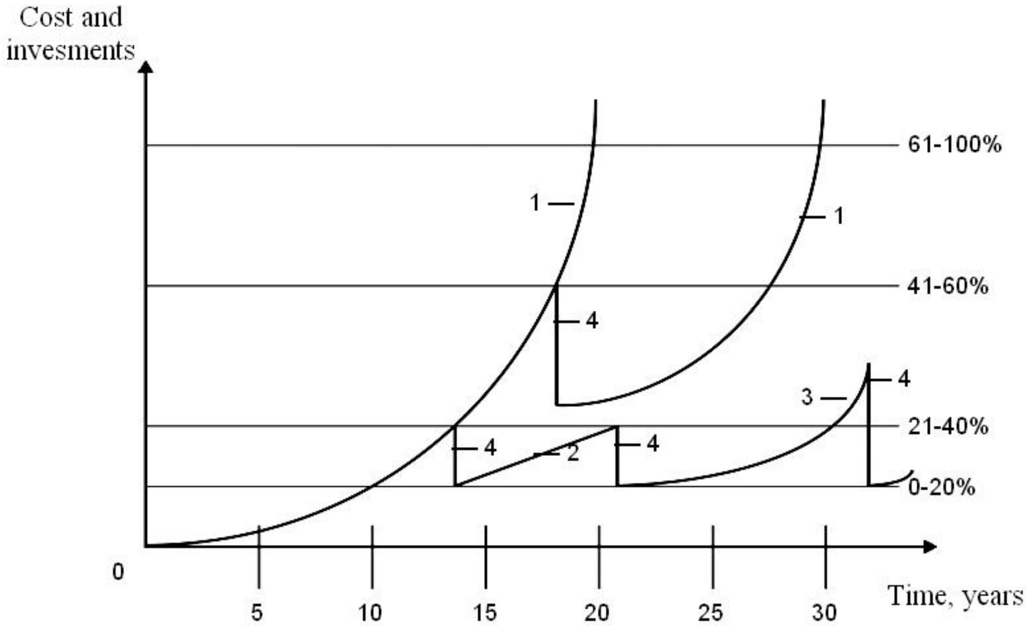

Figure 4: Changes in costs and investments during the construction operation period

Fig. 4 shows possible changes in costs and investments depending on the maintenance and reconstruction model of a building. Here: 1 – curve of natural deterioration of the construction; 2 – curve of construction deterioration when effective maintenance is performed; 3 – curve of construction deterioration when maintenance is performed; 4 – repair works of the construction.

Construction maintenance system and its management make a strong impact on the efficiency of construction operation. Therefore the creation and practical implementation of the management model of this activity has a strong practical and educational significance.

The transformation of management systems is strongly affected by the development of different studies and the practical application of their results. Facilities management cybernetics model might be created on the basis of the achievements in theory, applied mathematics, informatics and economics studies. Practical application of the facilities management cybernetics model determines the purposeful, reliable and effective functioning of an enterprise [12]. However, in practice this management model of an enterprise might be implemented only with sufficient normative, methodological, informational and legal resources of the management system [5].

Fig. 5 presents the scheme of a construction management cybernetic model. Such cybernetic interpretation of construction management allows to understand better the essence of construction management as well as to apply the main principles of such management for the achievement of the goal.

Fig. 5 gives systematical elements of the management model: resources, facilities management process, management apparatus, results, control information, regulation, inner and outer environment of the system.

Resources describe the totality of all means and devices necessary for the implementation of constructions management process. The structure of the resources and their provision intensity depend on the peculiarities of implemented constructions management solutions.

Facilities management process is described as a purposeful and effective performance of interrelated logically based activities when implementing rational (optimal) project solutions.

Results are systematical elements describing the final or transitional constructions management result expressed in the system of indices. This might include indices expressed in physical (material) or economical (efficient) indices, e.g. parameters characterizing technical state of a construction, amount of works performed, amount of costs, etc. The system of such indices is used for the control, analysis and correction of solutions. The creation and practical application of the index system determine the efficiency of construction management.

Control information is used to detect the variations of constructions management processes.

Regulation. Two principal systematic elements are regulated: resources and constructions management processes. On the basis of the regulations the variations of constructions management processes are eliminated and further rational (optimal) development is ensured.

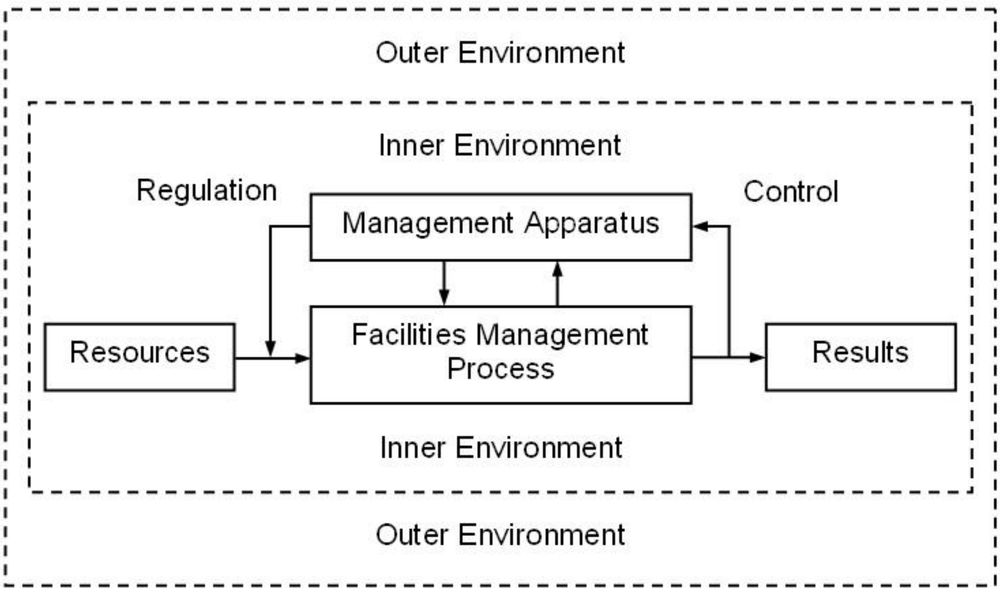

Figure 5: Scheme of the facilities management cybernetic model

Facilities management cybernetic model is a universal instrument that may be effectively applied in practice [10].

3. Preparation of Facilities Management Specialists in Lithuania

After Lithuania restored its independence in 1991, the transformation processes occurred in all spheres of activities. During this period the system of education and specialists training changed, too. The top priority was given to the transformation of the training system of different specialists as in the future the education, qualifications and learning of Lithuanian citizens will strongly influence national competitiveness and welfare of inhabitants of the state. The education and study system of Lithuania is affected by the development of market economy, the internationalization of all processes as well as the traditions of national culture [5, 6, 9].

The changes in functions and structure of Lithuanian economy determine the demand for certain specialists. As the experience of certain European countries shows, good economical results and high living standards may be achieved even without any material resources. In such case topical issues become education system and preparation of different specialists.

Internationalization processes gives more freedom for capital exchange and people movement as well as creates better possibilities for the development of economics and other fields of activities. On the other hand, it also sets new requirements for the professional training level of specialists and the application of scientific achievements in practice. This will be a top issue when determining the competitiveness of national economical systems in the international market [5, 6].

There is a three-stage study system in Lithuanian universities: background studies (bachelor's degree), master studies and scientific doctor studies.

Kaunas Technological University prepares specialists of different fields. All study programs were formed and implemented gradually, on demand, under suitable conditions and possibilities. Currently, a new master program suitable for Lithuania's economy – "Properties management" - is under implementation. This program comprises complex studies of construction project management, however most attention in this program is paid to the studies of facilities management activities.

Facilities management might be studied by bachelor graduates of construction engineering. The demand for such kind of specialists is constantly increasing in Lithuania. Objects of the activity of facilities management specialists might include various enterprises and organizations: industrial or commercial enterprises, offices, hotels, gas stations, hospitals, living complexes, educational institutions, etc. This might be functioning or temporally non-functioning objects [13].

4. Conclusions

The term construction project management appeared in scientific and practical terminology in Lithuania about 10 years ago. The term facilities management started to be used about 5 years ago. Currently, those interrelated activities have become particularly important in Lithuania. This might be explained by two reasons: 1) the amount of construction works is rapidly expanding and makes up 20-30% per year; 2) 70% of all investments are used for renovation, modernization and reconstruction of old buildings.

Thus, the demand for construction project managers is constantly increasing, and more attention is paid for the maintenanc3e, modernization and reconstruction of existing buildings. Moreover, enterprises of different business activities are trying to develop their competitiveness by reducing the functional costs of their activities. Such cost reducing possibilities might be detected in the construction maintenance and management system. As the tendencies of the development of enterprises show, those functions are often transmitted to certain specialized companies, which results in cost reduction by 30%. The effective functioning of construction maintenance enterprises is mainly determined by the selection of an optimal construction technical maintenance model as well as efficient application of investments for the modernization of buildings. To solve those problems, scientific studies need to be performed and best practical recommendations are needed.

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PUBLIC PRIVATE PARTNERSHIP: A SERVICE INNOVATION The Treasury Building case

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Abstract

A Public Private Partnership (PPP) contract combines the competences of a client, a bank, a designer, a construction company and a facilities manager, to finance, design, build and manage a building or an infrastructure.

It is a service innovation analysed through a case study: the PPP/PFI Treasury Building refurbishment and operation project in London. The analysis method is the Barcet and Tannery one [1], specifying the service as an aim, as a concept, as a process and using specific means and resources. PPP is a process service innovation, following a "methodological trajectory", which is the result of a change of competences and technical (material and immaterial) characteristics [2].

The main innovation through PPP is the combining of usually separated competences: client, architect, construction firm, facilities managers and users. This combining of competences is revolutionary in an industry where design and build have been for a long time separated from facilities management and use. This combining competences innovation is just beginning through a quite long learning by doing process.

Keywords: Public Private Partnership, service innovation, service key performance indicators, competences, facilities management.

1. Introduction

Most of the time, government or local authorities fund public buildings and infrastructures, and the building of the facility and its operation after completing are separated. On the one hand, the construction of the facility is provided by designers and construction firms through public procurement (design bid build, design and build, construction management)1, on the other hand,

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- [1]for a comparison between the different procurement procedures, see for example Konchar and Sanvido [3] for the US and UK procurement processes and the special issue of *Building Research and Information*, edited by Graham Winch, on procurement procedures in the European Union [4].

the public authority manages the operation and maintenance of the facility itself and with sub contractors (for heating, lifts, cleaning…).

Public private partnership (PPP) is a new way to finance, build and manage public buildings and infrastructures. Usually, in a PPP process, the public authority negotiates, through a competitive procurement process, a single contract with a private consortium specifying the funding, the design, the construction and the operation, for ten to forty years, of the facility. The public authority pays the investment and the operation through annual rents after the completion of the building. When the contract is achieved after ten to forty years, the facility is owned by the public authority. PPP is a feature of ongoing change of the construction sector, from the structures to the service [5] [6].

2. A service innovation

Even if the facility may be different on technical aspects through PPP, in comparison with a usual public procurement, this new way is obviously not a technological innovation. It is a service innovation

Gallouj [2] has highlighted five kinds of services, namely: « quasi products » (whenever the service is highly standardized), operational or manual services, informational or relational services, intellectual or professional services, and finally the packages of products and services.

The final service of a PPP process is the package of a product (the building) and a service (the management of the building),

Sundbo's typology [7] inspired by Schumpeter's one [8] specifies four service innovation categories:

- Service innovations: new service,
- Process innovations: change in the service elaboration procedures,
- Organizational innovations: change in the management modes,
- Marketing innovations: marketing, sales, and so forth.

PPP practice is a change in the package (building plus services) elaboration procedures; it is fundamentally a process innovation.

Gallouj [2] defines a service as a "set of characteristics and competences", the final characteristics of the service Ym resulting from the simultaneous mobilization of competences (coming from the service provider -Cp- and the client -C'q-) and technical characteristics Tn (material and immaterial). Innovations are particular movements of those competences and characteristics.

According to him, service innovations evolve according to different possible “innovation trajectories”, namely:

- the material transformation trajectory ê M (Y), which corresponds in the alteration of the material basis of the service,
- the information processing trajectory ê I (Y), corresponding to new data, new uses of data, network sharing of information, etc,
- the methodological trajectory ê K (Y), dealing with the implementation of formalized methods for knowledge processing,
- the « pure » service trajectory ê C (Y) corresponds to the direct mobilization of competences, regardless of any material, informational or methodological support.

PPP is a service innovation evolving essentially according to a methodological trajectory through formalized methods, even if it normally makes necessary the use of new data and if alters the material basis (the building) through life cycle cost design. We will highlight the weight of the implementation of new formalized methods used to specify and to control the PPP process.

We have already analysed service innovations in the construction sector [9] [10]. How to analyse PPP as a service innovation? To study and set up a service innovation, Barcet and Tannery [1] suggest a method in four analysis levels summed up in the following table.

Table 1. The service innovation analysis method

Analysis level	Question	Topic	Meaning
1. The client system	What for? Whom for?	The functionalities	The service as an aim
2. The result of the performance	What?	The service product	The service as a concept
3. The supply system	How?	The performance	The service as a process
4. The means and resources	What with?	The tools, methods, information, technical means, skills, competences	To implement, or to obtain, means and competencies

From Barcet and Tannery (1998)

To be more specific, a PPP case will be analysed: the refurbishment and the operation of the Treasury Building in London. This project is one of the ten PPP cases studied in the UK, Italy, Denmark and France, by a French team, assisted by European experts [11] 2. The project is one of the notable British "Project Finance Initiative" (PFI) investments, in the political frame specified by the Conservative government in 1992, amended by the Labour government in 19973.

3. The service as an aim

The first analysis level is the service as an aim, the client system. Her Majesty Treasury (HMT) had three main goals through this PPP/PFI refurbishment project of its head offices:

- To spread the payment of a significant investment, in a context of low level of financial public means,
- To design a building to back a new business process in the ministry, focused on a team and network way of working more than a hierarchical one,
- To provide a high level of day to day service to the employees.

Usual public procurement systems do not allow differed payment of a public investment. Conversely, to design a building to back a new business process and to provide a high quality service to the end users are normally possible through usual public procurement procedures.

[2] Then this team made the framework of a French Public Sector Comparator (PSC), available at www.fondation-igd.org/ [12] and the PSC dedicated to the French hospitals. This PSC is included in the French PPP guide for hospitals, available at www.mainh.sante.gouv.fr/ppp.aspx [13]
[3] On recent evolution of British PFI, see Allen et alii [14], Weill and Biau [15], and the following websites: www.partnershipsUK.org.uk [16] , www.4ps.co.uk [17], www.nao.org.uk [18].

4. The service as a concept

The second analysis level is the service as a concept, the service product. The concept offered by the PPP/PFI process has two main characteristics:

- The private partner pays the investment, the public authority spreads the reimbursement through rents paid during a long period, the first rent being paid after the completion of the building,
- A single team, dealing with the funding, the design, the construction and the facilities management is responsible for the package, refurbished building plus the services provided for a long period.

This concept, in comparison with the usual public processes, is a very innovative one: commonly public procurement plans a payment of the investment by the public authority during the design and construction time, and separated processes for construction and facilities management.

5. The service as a process

The third analysis level is the service as a process, the supply system. The PPP/PFI process has four main characteristics:

- A new procurement system with, in the case of the Treasury Building, two tenders: one for the package building and services, one for the funding,
- A transfer of risks from the public authority to the private consortium,
- The valuation of the transferred risks in the amount of the rent,
- A long term partnership between the two parties.

In 1995, an invitation to tender was issued for the refurbishment and operation of the HM Treasury’s offices in London. Exchequer Partnership was selected in September 1996 as preferred bidder after a competitive procurement process, but Labour Government elected in 1997 considered it inappropriate to proceed at that time. Following a review of the project a contract was signed in August 1999. HMT had also to set up a new tender on funding which was concluded in January 2000 [19]. The facility was successfully delivered one month early in July 2002, when payment of the unitary annual charge for 35 years commenced.

The two parties negotiated a complex contract specifying the package design, refurbishment, hard and soft facilities management by Exchequer Partnership (EP), a Special Purpose Vehicle Company, created by a construction company (Bovis Lend Lease), a developer (Stanhope) and a facilities manager (Chesterton), and the funding through index-linked bonds insured by Ambac (monoline insurer). Johnson Workplace then controlled Chesterton. The facilities manager was no longer EP's shareholder. Forster and Partners are the architects of the project. Figure 1 sums up the present construction and property business system.

We have studied the first half of the refurbishment, the second one, specified by another PFI contract with the same partners, is in progress.

The risks allocated to the private consortium are:

- Obtaining Planning permission and listed building consents,
- Design and construction compliance to achieve the occupier brief and deliver output brief performance,

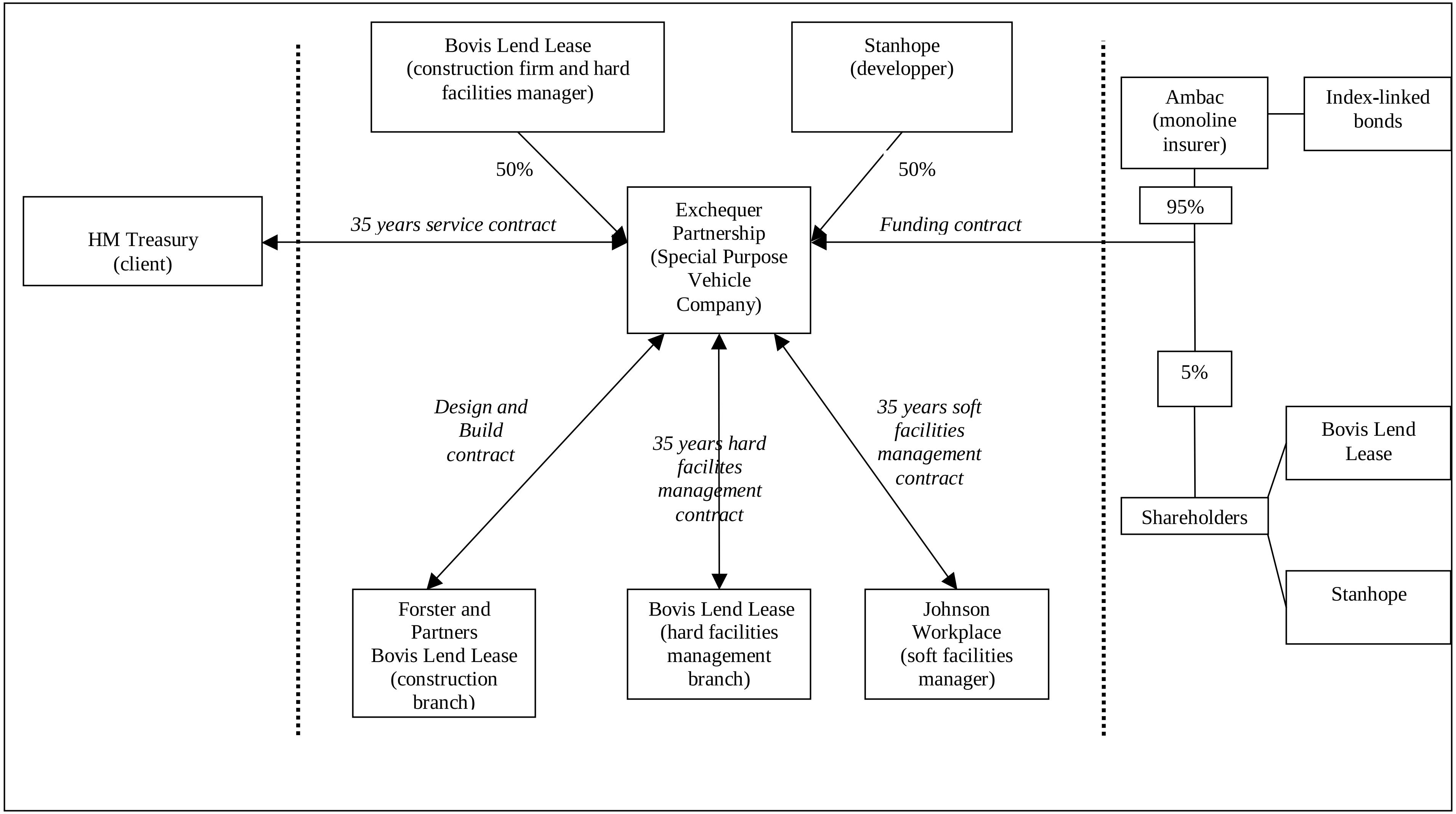


Figure 1. Treasury Building PPP/PFI project : the construction and property business system

- Construction and latent defects risk, which was significant in a poorly maintained 100 year old building,
- Service delivery risk, which lasts through the life-cycle of the facility. Many of these risks were then re-allocated to the FM sub-contractors by Exchequer Partnership (EP), although these risks were capped and above a threshold are retained by EP,
- Bankruptcy risk. Should EP fail, Ambac are obliged to step in to assure service delivery,
- Regulatory changes requiring changes in the output or occupier briefs,
- Letting risk i.e finding a tenant for other half of the building.

The risks shared include inflation, in that the unitary charge is index-linked. The risks retained by the Treasury include changes in user requirements implying changes in the output or occupational briefs other than those required due to changes in national regulations.

The valuation of the project and the transferred risks is embodied in an annual unitary charge of £14M during 35 years. The cost of the project was £141M, of which £112M represents design and refurbishment. The amount of £29M corresponds to the negotiation costs and the funding costs, among them, preparation and negotiation costs were about £7M for Exchequer Partnership.

The PPP/PFI process involves a long term partnership between the parties. According to the interviewees, this partnership works very well. In our opinion, success factors for such a partnership are:

- The willingness of the parties for the success of the HMT head offices refurbishment in a PFI process,
- The high level competences of the partners,
- The quality of the tools and methods (see infra)
- The profitability of the contract for the private partner.

No specific information is available on the profitability, but we think that it is very difficult to manage a serene partnership, when the contract has been under priced by the private partner and is not profitable4.

6. The methods and the competences

We are dealing now with the fourth analysis level suggested by Barcet and Tannery (1998), the means and resources one: tools, methods, information, technical means, skills, competences.

Our analysis highlights five aspects dealing with the means and resources:

- The competitive procurement process,
- The funding method,
- The occupier brief and associated tools,

[4] See for instance the problems of the under priced STEPS deal between Inland Revenue and Mapeley [20].

- The output brief and tied tools,
- The combining of usually separated competencies.

We will also underline some lacks, especially the need of operating costs data bases.

We did not get into details to analyse the competitive procurement process because we chose to study the Treasury Building case more than one year after completion of the refurbishment. In opposition to the usual procurement one, the PPP competitive procurement process is a performance-based one. The occupier brief and the output brief specify the results to be obtained but do not define the solutions to meet them. The private partner elaborates the practical means to reach the objectives and to measure the output.

The counterpart of this very productive process is the time and the cost. The negotiation between the public authority and the preferred bidder is long and pricey. The complexity of the long-term contract explains a part of the cost, but solutions have to be fund to moderate the cost of PPP/PFI contracts5.

The Labour government asked HMT to set up a separate tender for funding. An opportunity to innovate was created. Bank financing and bond financing competed. One solution was funds provided by one or several banks, through a negotiation between the project company and the bank. The other solution was funds provided by bond investors, through an agreement via an intermediary, a bond arranger.

Bond financing was chosen for three reasons (NAO 2001):

- The project length, at 37 years, including design and construction, is 4 years longer than the longest period for which banks would have been willing to lend,
- Index-linked finance can be cheaper than fixed rate finance and favours bonds,
- Monoline insurance of a bond reduces the interest rate bonds investors will require and increases the attraction of a wrapped, or insured, bond finance relative to bank borrowing.

Although bond financing was more competitive than bank financing at the time of Treasury funding competition this may not be always the case.

The occupier brief described the required functionality of the facility in technical terms. As we noticed one objective of HMT was a design to back a new business process in the ministry, focused on a team and network way of working more than a hierarchical one. This involved an occupier brief focused on a shift from wholly cellular to partially open plan offices. This activity included a pilot open-plan office. This choice and technical aspects were discussed in many meetings between the design team and Treasury staff, dealing with space design, access control and security, health and safety, information technologies, lift, signage and way…

[5] Public task forces promoting the best practices, technical expertises put in common, free practical PPP guides, standardised contracts or parts of contracts, control of the cost of the advisers are some solutions; but the problem is complex. We just notice that PPP can also concern, like in Italy, small and non complex projects involving local authorities and regional construction firms, without many advisers.

According to the architects, the quality of the occupier brief is one of the success factors of the project. After completion of the refurbishment, the Post Occupation Evaluation is the tool in relation to the occupier brief. This survey, made six months after moving in, dealt with:

- Place: aesthetics, temperature, lighting, cleanliness, workplace, space for concentrated work, space for collaborative work,
- Technology and services: telephones, filing, printing, shredders, information technologies, catering, reception,
- People and processes: feelings, communication, openness and transparency, flexibility in working practices, productivity and innovation.

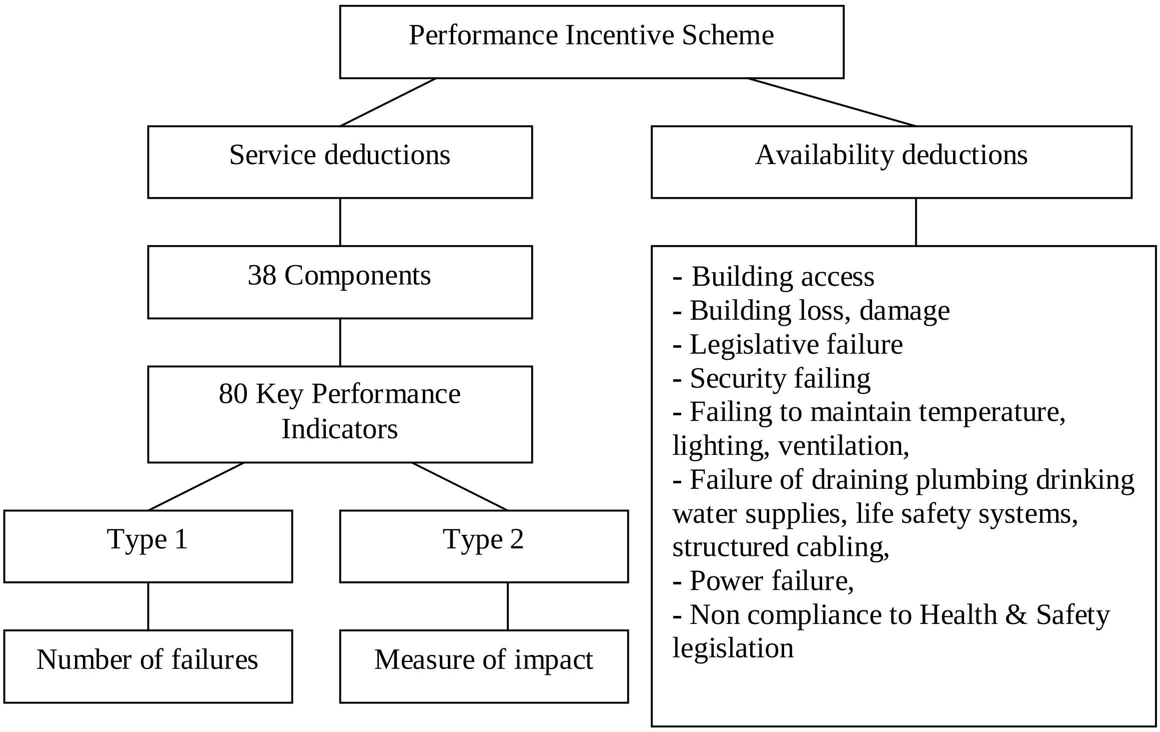
The level of satisfaction was high: 83 % of respondents said that their working environment had improved in terms of functionality and afforded more opportunities for collaboration. Some critics concerned temperature monitoring, noise and privacy. To change attitudes regarding the suitability of open areas for "private" conversations was wished.

The output brief and tied tools sound very innovative. The output brief deals with the facilities management issues in terms of the service delivered to the users. Facilities management deals with eleven topics:

- Hard services: Mechanical, Electrical, Plumbing (MEP), lifts, building fabric, pest control, furniture,
- Soft services: security, cleaning, catering, waste management,

help desk and general facilities management being used for hard and soft FM.

A Performance Incentive Scheme specifies service and availability deductions. Service deductions concern 38 hard and soft facilities management components and are measured by 80 Key Performance Indicators (KPI). The 67 type one indicators involve financial penalties, the 13 type two indicators do not involve financial penalties.



Source: Exchequer Partner

Figure 2. The Performance Incentive Scheme

Audits of FM made four times per year by the monocline insurer and permanent control by HMT facilities managers fill up this rather sophisticated service control system.

The last topic dealing with methods and competences concerns maybe the most potentially innovative aspect of PPP: the combining of usually separated competences. Figure 3 sums up the separation of the different mobilized competences in separate contracts in a Design Bid Build process. Figure 4 illustrates the combining of the mobilized competences through a PPP long term contract.

The client as investor and as facilities manager, the architect, the construction firms, the facilities management subcontractors work usually in a separate way.

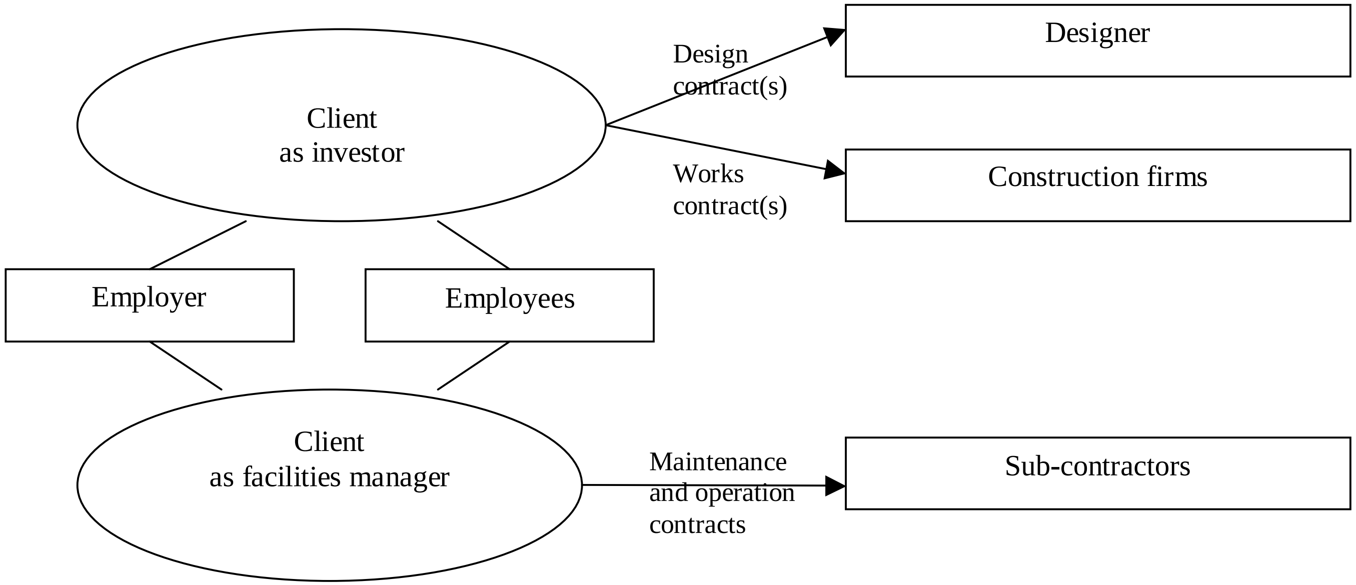


Figure 3. The separated competences in a Design Bid Build process

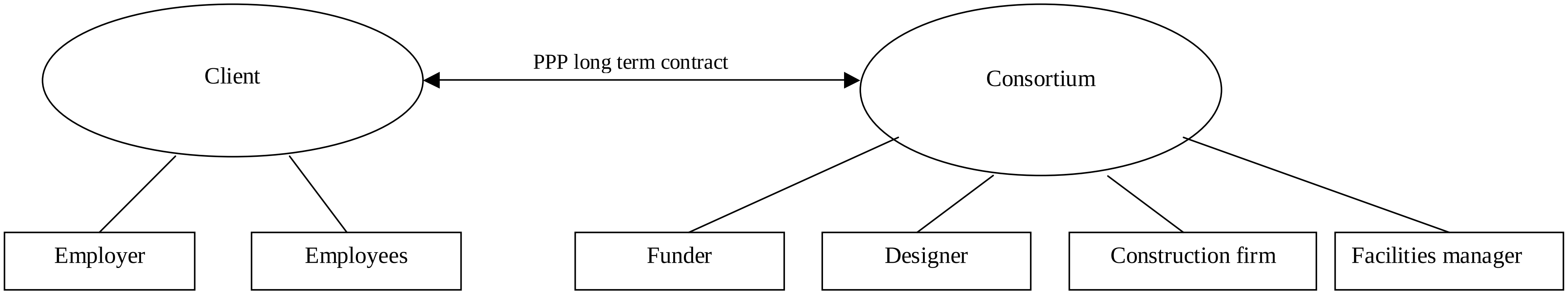


Figure 4. The combined competences in a PPP process

The PPP process obliges them to work together, the result of this combined work being written down in a long term contract. For the first time, the architects designed a building by working with the users and the facilities managers. They told us that this process forced them to look at the project in a new way. The combined competences of the architects and the facilities managers allowed to improve many aspects of the project: heat summer, ventilation, lighting, windows curtains, wall paint, carpet quality etc. The sophisticated service control system is also the result of combined competences of the client and the facilities managers.

The players are not used to do so. PPP is a “learning by doing” process which requires time to learn how to combine the competences. This implies a cultural revolution in the construction industry. For ages, construction and facilities management have been separated. New ways to work together as client, architect, construction firm, facilities managers have to be invented.

This also makes new tools necessary. For example, operation costs data bases are needed. Such data bases, giving the maintenance and operation costs and the link between them and the investment costs, are necessary. There must be practical life cycle costs data bases for each kind of building (offices, hospitals, schools, prisons…), based on real costs, not theoretical ones.

Those data bases and contract contents could be designed in a sustainable way, with new incentives, for example the gains of energy consumption being shared between the public and the private partners. Long term PPP contracts are a very good opportunity to design, build and manage buildings in an environmental friendly way.

7. Conclusion

The Barcet and Tannery (1998) method offers a comprehensive view of a service innovation. Success factors concern each of the four analysis levels. The players have to answer very clearly the strategic questions dealing with the service innovation: What for? What whom? What? How? What with?

The high level quality of the tools and the combined mobilized competences are key success factors of the innovation. We agree with Gallouj (2002) when he specifies a service innovation as the result of a change of the service provider’s and client’s competences, and technical (material and immaterial) characteristics of a process. The analysis of a PPP/PFI project, such as the Treasury Building one, a process service innovation following a methodological “trajectory”, confirms this definition.

The potential of innovation through PPP sounds high. The main innovation is the combining of usually separated competences. This combining of competences is revolutionary in an industry where construction has been for a long time separated from facilities management and use. The efficiency of the PPP process is that the players are obliged to write down in a long term contract the result of their innovative cooperation.

Innovation is just beginning. Practices will change progressively. Some innovations are still potential, such as practical life cycle costs data bases and long term sustainable facilities management.

Actually many PPP innovations could be used to improve the usual Design Bid Build and facilities management processes. Accurate occupier and output briefs, cooperation with the facilities managers and the users, financial incentives to make the works time shorter, multi service contracts, performance indicators, financial incentives for efficient operation are examples of PPP best practices which could be employed to improve usual procurement and facilities management processes.

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Towards the New Criteria of Elderly Housing by the Model of Independent Mobility

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Abstract

The approach of the new criteria starts from the existing knowledge, looks the needs and wishes of the seniors and uses the Models of Independent Living and Mobility as means of organising the design knowledge. The approach of the models is qualitative. The outcome of these concepts is shows in so called the activity cards, while the activity was chosen as a dominant factor from the four angles studied in this project of the elderly habitation: activities, abilities, resources and qualities. Another main variable of the Models is resources, which represents more the housing providers approach to the independent living of elderly. The end-user oriented housing design is looking the habitation from the residents perspective, and even in housing provision the activity based approach to habitation will increase while both market pull and technology push domain the design. The Models emphasise the idea that a starting point can be anywhere in the ball: activities, resources, qualities or abilities − depending on the situation and what kind of point of view is taken.

Keywords: housing, design criteria, senior citizens, independent living, end-user requirements, design criteria, Design-for-all, housing surroundings, Model of Independent Mobility

1.Background

This paper is drawing much from the EU Fifth Framework project Elderathome, The Prerequisites of the Elderly for living at home: Criteria for Dwellings, Surroundings and Facilities (QLK6-CT-2000-00405). The focus of the EU-project Elderathom is to develop criteria for dwellings, equipment, surroundings and services so that elderly people can live longer independently at home. Despite the fact, that large amount of general and detailed information is available about the expert knowledge on housing, surroundings and services of the elderly, this information is non-uniform and in a different level in each European country. Summaries and in depth focus on the basic criteria have been identified necessary. Improving the independent living conditions of the existing housing stock has been targeted. The idea has been to improve functioning, in order to obtain better convenience and usability by the elderly. The project will make an inventory of the state-of-the-art of criteria of products and facilities necessary for independent living, identify the wishes and needs of the elderly, identify the criteria for the manageability of housing and suggest new developments in order to contribute future independent living.

If comparison for finding wrights or wrongs, good or bad is not fertile, the identification of similarities and differences internationally in recommendations, regulations and design guidelines make it possible to understand national features and to learn from others when respecting the facts of universal human existence and housing phenomena due to various climatic conditions and rich housing traditions in Europe.

There are three forms of preventing the difficulties due to the impropriate housing condition for the aged residents: renovation and repair of present housing, moving or relying on assistive services, which substitute the difficulties due to the impropriate housing condition for the aged residents. Housing should in the first place satisfy the basic housing needs for shelter and the surroundings are designed accordingly. Apart from the technical aspects of the surroundings of the building, also the quality of the wider living environment is considered. In many cases, it is difficult to make difference between these two approaches to design. The expected better standard of living of elderly sets new questions. What are the modern targets of the good living and what is known about the physical and mental health promotion of elderly? How they have to be taken into account in design of housing, housing surroundings and facilities. Furthermore, how the housing and service providers as well as facilities management can promote new lifestyles of elderly?

The willingness of the elderly to renovate and repair their homes counts. The possibilities of renovating or repair existing housing stock are crucial, while elderly are not very willing to move although that alternative is not totally excluded either [1]. It is questionable if the use of assistive services is a good solution although in many cases a necessity. Renovation or repair is a one-off investment, but services cost repeatedly. The expectation of too high cost effects due creation of too many recommendations and regulations is a reason for deliberation in actions of authorities. It is an interested starting point for the project, while both authorities and voluntary work can benefit from accomplished new knowledge. On the other hand, also such businesses in this area as housing and service providers and facilities management can use this opportunity to reach knowledge of if the end-users or the customers are ready to bye their products.

It is very important to understand and to remember that the new criteria have no intentions to form any kind of minimum or maximum standard not to mention to aim to become a regulation. It is a checklist covering issues related to elderly housing for understanding and checking the situation in each case of elderly habitation.

Housing challenges many fields of sciences. It is a combination of social sciences, cultural history and ethics, economics and housing technology: transport design, town planning or zoning, landscaping, civil engineering, architecture, interior design, structural engineering, and HVAC, electricity and smart house technology. This challenging holistic approach includes also ecological and environmental psychological aspects. The knowledge of economics can be found out rather seldom from national economics, except from municipal economics and economies of households, but the more often from geographical economics, building economics, life-cycle-cost analyses, and from properties and facilities management.

The United Nations General Assembly adopted the UN Principles for Older People, in the year 1991. These call for action in many areas, among them:

− Independence: Older persons should have access to food, water, shelter, clothing, health care, work and other income-generating opportunities, education, training, and a life in safe environments.

− Participation: Older persons should remain integrated into community life and participate actively in the formulation of policies affecting their well-being.

− Care: Older persons should have access to social and legal services and to health care so that they can maintain an optimum level of physical, mental and emotional well-being. This should include full respect for dignity, beliefs, needs and privacy.

− Self-fulfilment: Older persons should have access to educational, cultural, spiritual and recreational resources and be able to develop their full potential.

− Dignity: Older persons should be able to live in dignity and security, be free of exploitation and physical or mental abuse and be treated fairly regardless of age, gender and racial or ethnic background.

Besides the regulations the Finnish housing designers and planners mainly have used the recommendations of the RT direction cards published by The Building Information Foundation (RTS, http://www.rts.fi/english.htm) and occasionally more detailed directions and recommendations including in the TTS Institute‘s Home Economic bulletins. VTT has established a product called VTT Building and Transport ProP® (Requirement Management System). It is a classification, which takes into consideration Finnish and international standards, norms and classifications. It includes all kind of housing and surroundings and is not specified in elderly. Similar classification is: PAYCO in Spain which automatically translates the clients' (with little or no previous experience) requirements into design specifications.

An electronic database called ARVI[1] (arvi.projekti.com) is under the way to become an addition source of valuable information of housing design criteria concentrating on the criteria which is taking into consideration the housing needs of the elderly and disabled. Also new experimental

[1]A method for design of housing for people with limited abilities in mobility and activity.

databases have been created such as VIRAPS[2] (http://viraps.uiah.fi/), which aims to an automatic system suggesting housing designs for the end-users who enter information of their housing needs into database.

There are two certificates for elderly housing in the Netherlands the Woon Keur Certificate (www.woonkeur.nl) and Seniorenlabel. The Europa House Group is constantly working together with the rules for housing in general, not particularly for elderly, but also taking the needs of special groups carefully into consideration.

A large group of people - people with disabilities, older people, children, tall and short people, people with prams, travellers carrying heavy luggage - can all encounter barriers and obstacles in the built environment. The "European concept for accessibility" states (1996):

> *"To ensure equal chances of participation in social and economic activities, everyone of any age, with or without any disability must be able to enter and use any part of the built environment as independently as possible."*

European Manual for Accessible Built Environment was formulated at the end of 1980's and the firs version of the manual was printed in 1990. The idea to write such a manual was initiated by the Central Co-ordinating Committee for the Promotion of Accessibility (CCPT) and the same organisation produced the manual. The objective was to bring about new initiatives to improve the accessibility of the built environment in the European Community. The manual is also hoped to help in standardisation work.

According to the European Manual for Accessible Built Environment all buildings open to the public must be fully accessible, while working places and dwellings can have a standard of accessibility in accordance with the rules of the individual country. Such buildings can be houses, shops, theatres, restaurants, public telephones, banking services, information kiosks, self-service systems, public transport facilities and places of work. In order to use an information and communication technology terminal or other ICT system, the built environment around it must be accessible.

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[2] The Internet-based VIRAPS service brings user-orientation into the housing industry by connecting the databases of the various companies involved in the building process. The VIRAPS service allows customers to search the database for suitable apartments in their preferred areas. Customers planning their apartments with the VIRAPS service can customize them according to their wishes and make changes in their interior design. These decisions are divided into environment, construction and infill levels. The integrated cost-calculator keeps customers informed about how their choices affect the final cost of the apartment. User-orientation of the VIRAPS service benefits both customers and companies: customers can balance their needs and desires with the right price, while the companies can increase their turnover and adapt to the markets faster and more accurately.

2. Models of Independent Living and Mobility

The Models of Independent Living and Mobility of Elderly include four main elements or variables: activities, abilities, resources and qualities (Figure 1., Figure 2.). Models describe the idea of different variables needed to be taken into consideration when promoting wellbeing and supporting independent living at home. The Models represent the holistic approach in which different relevant factors are integrated. The variables ensure for example that making reparations meets the requirements of users.

Figure 1: The variables of models of Independent Living and Mobility

The normative mode (the form) of criteria shown in the activity cards (Table 1. to be published at www.vtt.fi) is telling both of the qualities of phenomenon and the reasons why one should have criteria of that kind formulated in easily opening manner. The expressions are focusing on rather needs and wishes than on solutions.

The Models of Independent Living and Mobility are means of organising the knowledge. The approach of the models is qualitative. The outcomes of these concepts are shown in the activity cards, while the activity was chosen as a dominant factor from the four angles of the Models. Another main variable of the Models is resources, which represents more the housing providers approach to the independent living of elderly. The end-user oriented housing design is looking the habitation from the residents perspective, and even in housing provision the activity based approach to habitation will increase while both market pull and technology push domain the design.

The approach of domestication is starting from the facilitation of activities of everyday living and the approach of the housing provision starts from the general principles of quality requirements of housing, which can be realised by certain business activities. The Models emphasise the idea that a starting point can be anywhere in the Model: activities, resources, qualities or abilities − depending on the situation and what kind of point of view is taken.

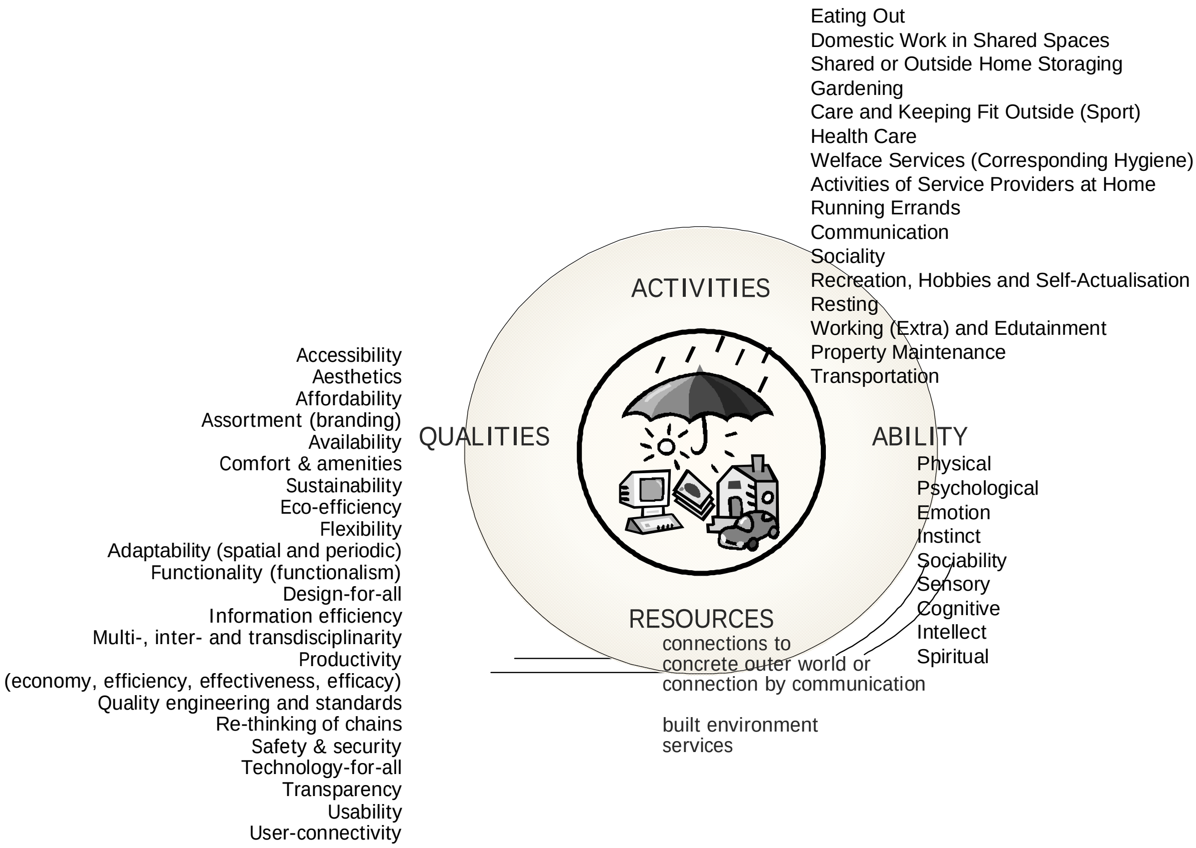

Figure 2: The Model of Independent Mobility of Elderly.

2.1 Activities

Common housing activities are care and keeping fit, eating, personal hygiene and dressing, moving, recreation, communication and self-actualization, sleeping and resting, gardening and maintenance, housework and storage. They were used in the Model of Independent Living. The Model of Independent Mobility is covering the same activities but looks at activities taking place outside home or activities, which connect home outside surroundings and services (Figure 2.). They can be compared with the Activities of Daily Living (ADL)-indicators, which are often used in the geriatric of a functional capacity of elderly. The activities are divided into the Physical Activities of Daily Living (PADL) and the Instrumental Activities of Daily Living (IADL). However, the new criteria look the activities also from the point of view of abilities when the ADL-indicators look them rather from the point of view of disabilities and limitations in everyday living. The criteria of surroundings can be tailored by the needs of accessing services, the activity level of the senior tenants and not only the current physical and psychological health condition but rather the promotion of health and function − even disease prevention in old age.

Mobility is a basic activity of all activities, which are related to surroundings of homes, the near neighbourhood and connections by information and communication technology and media from home.

2.2 Resources

The surroundings are defined as the area connecting the inhabitants to the outer world, services, activities and social life. The connections and access to services, transport and relatives, friends and other people are needed. This connection can be a concrete one as a corridor, a courtyard, a path. It can be a more abstract one as a link via communication technology or even as an access by virtual reality. These are the resources.

Apart from the technical aspects of the surroundings of the building, the quality of the wider living environment or neighbourhood has also been considered. From the geographical approach can be found that the housing surroundings does not mean the housing unit scale, but the building site condition and in certain extent the neighbourhood, which during a standard house building processes means the street in front of house(s) and the connections to the public municipal services: electricity, water and sewage pipelines if needed, and possible gas or district heating pipeline, and connections to telephone and other communication networks. Within the Elderathome project the neighbourhood was the space within the walking distance from home and surroundings is the area next to the houses. The walking distance is dependent on the ability to walk, but often it means the distance within around 15 minutes' walk. This is for a healthy person roughly 1 km (or a few hundred meters more).

The area in focus is the connecting channel like staircases, lobbies, terraces, courtyard and possible garden, walkways, parking, back lanes and connections to information and transport systems: private vehicles: (airplanes), cars, boats, motorcycles, cycles, public transport and pedestrian and cycling pathways. Examples of resources can be given as:

- Operable building elements (fence, ports, doors, stairs, ramps, lift, locking with doorbells, door telephones and video monitoring)
- Active structures (automated doors, windows, thresholds, curtains, shadings, etc.)
- Storage rooms near entrance for walkers, bikes, skies, other sport equipment, etc.
- Entrance halls or other space for to move or bring in and out goods (groceries, deliveries, repair equipment or furniture)
- Telecottages (and satellite offices), meeting and banqueting rooms, extra quest rooms, space for welfare service or maintenance providers
- Technical and maintenance spaces
- Shelter (shelter for entrance, terraces, barbeques, separate storage buildings, etc.)

− Yards and gardens

− Seats and rest areas on housing surroundings and in the neighbourhood

− Hobby and recreation areas and facilities (plays, shared equipment, etc.)

− Possible domestic appliances outdoors

− Paths (walking paths, sideways, shortcuts)

− Back lanes and streets

− Neighbouring housing, nature and public buildings

− Personal transportation: access to vehicles and parking places or storages

− Public transport: stations, stops and platforms, information (signs, signals, labels and timetables)

− Surfaces, coverings and pavements

− Location of personal business, services or public transport

− Telecommunication – media connections (e.g. gable television, satellite dishes), telephone and data lines, gables and antennas, personal devices of home health care e.g. wearable devices – pendant alarms, vital signs monitors, alarms for safety and security systems (burglar, fire).

2.3 Qualities

There are a good number of qualities, which belong to the general concept of good housing practice or building and maintaining housing. Any of them cannot be left without attention when designing and facilitating built environment. Still, certain ideas of them can be named more important to the criteria of surroundings than those of the dwelling or services (Figure 2,). For mobility, the accessible design (accessibility) is one of the main considerations. Other important qualities for mobility, physical surroundings and connections are availability, Design-for-All, sustainability, re-thinking of chains, safety and security, user-connectivity, usability, Technology-for-All and transparency. Such qualities as availability, affordability, Design-for-All, user-connectivity, productivity, quality engineering and standards, usability concern all activities and are not mentioned in the activity cards separately. However, some of them are not very well developed in the context of built environment: user-connectivity, usability, Technology-for-All and transparency.

The quality of multi-, inter- and transdisciplinarity is not mentioned in the list while it is everywhere present. For the need of easy access to the activity cards, a hierarchy of the qualities is helpful.

Qualities are essential for good design in any case, and cannot be excluded in criteria, which aim rather to a general checklist than to detailed instructions. In a complex modern world the basis of the design principles can be even forgotten during the sophisticated design work and there are almost never too many checklists. Most of these qualities are well known in the context of housing and building. Some of them might need some specification in the context of elderly housing.

2.4 Abilities

The Elderathome project is focusing on those, who are in old ages:

- Able to live independently in an improved environment,
- Able to live independently in an improved environment and with services provided at home or
- Willing to live in an environment designed specially for health promotion.

The Elderathome project is not especially interested in those who:

- Are able to live independently in any environment or
- Have health problems needing specialised care permanently.

Not all elderly have severe disabilities, but the prevalence of disability or limitations is the highest amongst this demographic group. In the old ages the physical abilities, senses and cognition tend to weaken. The impaired abilities often lead to a need of outside help or arrangements in the dwelling and they are especially significant when considering independent living at home. The abilities, however, not the disabilities make the independent living possible. However, many elderly can trust their long life experiences and their good psychological and social skills as well as their mentality in the independent living conditions, if something unexpected will happen or despite the impairments of old ages [3], [9]. On the other hand, also these previously mentioned abilities might fail and cause problems. Some elderly are for example too lonely or too scared in order to live alone or independently, although their physical condition would allow them to do so.

The abilities for the Model of Independent Mobility were determined together with Veli Himanen on the basis of the work we have done on human and technological intelligence [4], on CEN/CENELEC Guide 6 [1] and the latest literature on psychology, e.g.[1]. They are as follows:

- Physical (dexterity, movement, manipulation, reach, seizures, strength, voice)
- Psychological (temperament, feelings, behaviour patterns; habits, addiction, motivation)
- Emotion (the consequence of bodily reactions and mental modes due to stimulus, or sensing and feeling)
- Instinct (genetically programmed behaviour)
- Sociability (social relationships, group behaviour, social life and norms)

- Sensory (hearing, sight, taste, smell, touch, balance)
- Cognitive (understanding, integrating and processing of information)
- Intellect (know, comprehend and reason; knowledge management, memory, learning)
- Spiritual (intelligence for creativity or for satisfaction of needs, intuition to reach tacit knowledge and handle instincts with intelligence, mental growth and transcendency).

3.Implementation

New criteria is suggesting concepts for lacking existing design criteria and formulating criteria out of them shown by activity cards (Table 1.). A starting for organising the existing design criteria was found from the accessibility strategy of the Ministry of Transport and Communications Finland [10] covering equally all people, feasible for independent living of elderly housing and surroundings especially after the problem of noise and lack of light and awareness were added, classifying problems of environment:

- Differences between levels
- Need of space
- Reaching distance especially when carrying items
- Orientation especially in finding ones way if sight is not good
- Balance in stairs, ramps and vehicles
- Reach of small people and wheel chair users
- Lack of strength in opening doors
- Complexity in use of technology and in understanding information contents
- Safety of infrastructure and maintenance
- Allergy; respiratory in particular
- Inequality caused by environment
- Noise
- Lack of light
- Lack of awareness.

Table 1: An example of an activity card.

Criteria	Variable		
	QUALITY	**ABILITY**	**RESOURCE**
Reaching distance It is important to reach certain basic services and being active on daily basis in the surrounding neighbourhood or in local village, while the visits to rural centres and cities are done more occasionally. It is easy and appealing to move, walk or run and reach the needed destination for running errands, reaching services, meetings and visits, promoting physical and mental health. There is possibility and adequate easiness to use private car. The uses of vehicles for reaching cf. Transport.	Accessibility Re-thinking of chains Sustainability Eco-efficiency Flexibility Adaptability Assortment Safety & security Functionality Comfort & amenities Aesthetics	Physical Psychological Sociability Intellect	The routes are short. The ramps are not too steep and long. There are enough and comfortable resting places available in the housing surroundings and neighbourhood, in the paths and especially on the way to stops and stations. Parking places near dwellings are safe and conveniently arranged. Parking garages are social secure and are good to manage. The sitting areas; seats and other public furniture are attractive. There are shelters in the mobility area. Because it is difficult to carry items such as groceries and equipment for activities, there can be lockers for temporary storing along the routes. For chaining of various transport modes there are locked shelters for vehicles or moving aids for periodic storing also in the near neighbourhood (e.g. parking of a walker) or in the stations are available walkers and rollers for use during walks. The housing complexes are in attractive scale and the opening up is conveniently arranged and recognisable. Town planning is based on the human scale as well as the use of car (cf. Transport).
Need of space It is easy to use a walker and cycle or bike (or use a preferred means). When running errands in offices etc. it is possible to have enough space provided for to operate and put and have things in a safe place.	Accessibility Flexibility Adaptability Safety & security Functionality Comfort & amenities Aesthetics	Physical Psychological Sociability Spiritual	Sufficient dimensions, finish, design and layout of: o Shared spaces and spaces for entering and exiting o Courtyard and garden o Paths, ramps o Parking places, pathway form the parking area to the home entrance o Streets, walkways and alleys o Stops and stations o Plazas

The end-user interview revealed that senior citizens are not necessarily aware of the possibilities how the housing can aid independent living [1]. The aim of the criteria is to raise awareness of how built environment can help the elderly and other parties involved to plan the possible changes for provision of independent living in their present homes. The new criteria form, in the first place, a framework and a checklist for the occupants, designers and service providers for common understanding of needed changes of individual senior citizen's habitation. The new model can be used in two ways:

− As a tool for analysing the existing knowledge and as a tool for formulating the comprehension of the habitation of the elderly and formulating a criterion out of them

− It can serve as a planning tool for empirical cases and be a generator of new ideas for implementation and criteria.

The thinking behind the existing criteria seems to be based rather on common habitation in cities and in suburban areas than that in the rural areas or surroundings of private housing. Living in block of flats or in other types of common housing arrangements are in focus. The new criteria of surroundings are not − at least purposefully − making this type of discrimination between the habitation and living styles of elderly. The existing criteria are numerous rather of limitations than of alternative advices and solutions when facilitating the independent living. The human disabilities and impairment lead the thinking. The new criteria of surroundings tend to suggest some advancement of this respect by looking also the abilities of elderly due to e.g. long and rich life experience and the freedom of selecting alternative living styles and surroundings. Not always, but in some cases the long life experience stand for better awareness of ones abilities and their relation to the possibilities in life in general and also of what is possible due to the surrounding conditions including built environment. The better understanding of life makes the social relationships and social skills valuable.

4.Conclusions

There are two tasks for the criteria of surroundings. They shall be designed to avoid obstacles such as:

− Insecurity

− Costly economics of facilities management (high housing costs - affordability)

− Distance

− Uncomfortable design

− Unattractiveness

− Bad weather

− Arguments against bad sociality and too small privacy

− Physical obstacles

− Lack of connections: parking places, public transport, etc.

− Attitudes of housing mangers and other tenants,

− Interim obstacles

− Lack of binding regulations that specify preciously the interpretation of the concept of housing and surroundings of independent living of elderly,

− Lack of European wide harmonised advisory guidelines

− Ignorance and lack of awareness of the effect of built environment for independent living of elderly

− Elderly housing has not been regarded as big business

− Laws and building norms are too weak to facilitate independent living of elderly

− .

Such examples of the obstacles can be mentioned as public transportation may be inaccessible and unavailable; attendant care services may be inadequate and dehumanizing; income maintenance programs and health care assistance can be inadequate informed; or community facilities and programs may be unresponsive and inaccessible. In addition, individuals may not be able to get out of their homes or get around inside because of architectural barriers. Even in the housing environment there are numerous issues which people confront. Landlords may discriminate against elderly people. Landlords and tenants can be patronizing and create problems for visiting home care attendants. Housing can be unaffordable, especially for people with low to moderate incomes. Large housing projects are often unsafe and may not have adequate accessible neighborhood facilities. Also, many communities do not have emergency housing hostels and facilities which are physically accessible.

On the other hand, they can promote the quality of life and make the every-day life not only easy but also enjoyable. This part is not very fully covered in the existing knowledge of independent living and housing surroundings and neighbourhood.

Some suggestions for bettering the situation can be made:

− Inform the market

− Coordination between countries in creation of housing norms and specifications (EU Directives)

− Close collaboration between politicians, technicians and citizens

− The will to co-ordinate all the agents involved and programme the interventions

− Including the knowledge of special housing and surroundings concepts as the independent living of elderly in the education of architects and building engineers

− Making fully clear who is responsible for applying new concepts

− A more accurate analysis of the effects of adaptations of built environment for independent living of elderly

− Identifying the areas where common requirements are most important

− Facilitating the change in built environment for the independent living of elderly by supporting financing systems (loans, allowances).

Kose [7] has stated good questions about the design criteria of built environment of elderly:

"Safety: To what extent should safety be pursued?

Health: How healthy[3] an environment can be?
Function: How convenient should a house be? (How does one distinguish convenience from laziness?)
Comfort: How would a stimulus-free environment affect a human being?
Economy: Who will eventually bear the cost?"

The criteria of surroundings is highlighting not only the problems with built environment but the criteria cover also the way of having fun, pleasure, environmentally comfortable. Resources include possible solutions without any prejudice to what is suitable to offer to elderly; it is their own choice and a right of all to choose from what or from the best engineers and architects can offer.

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Performance Based Building

Pekka Huovila

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Preface

This book highlights Performance Based Building (PBB) experiences from four continents as they were presented in the international CIB Symposium COMBINING FORCES in Helsinki in June 2005. Eighteen papers describing different PBB perspectives are classified into four sections. Fifteen presentations in the first three sections report the main outcomes of the EC funded PeBBu Thematic Network.

The first section starts by describing the structure and impacts of the PeBBu network followed by presentations of the main technical PeBBu Domains: life performance on construction materials and components, application of PBB to healthy buildings, innovation and design. The last paper in the first section extends the European networking to Australia and Asia.

The second section deals with the PBB framework and tools. The first paper makes a pan-European comparison of international classifications for performance requirements and building performance categories used in various evaluation methods. It is followed by a presentation of a decision support toolkit, which can be seen as a step towards an integrated platform for performance based building. After that a compendium of statements of requirements is reported. The last paper in this section bridges the PBB framework to the nD models in building and construction.

The third PeBBu section deals with performance based building standards and practices. It starts by giving an overview to regulations and finishes by discussing the construction product directive. In between, the procurement issue is described from the Danish perspective followed by sharing the Mediterranean and NAS (newly associated states) views on performance based building.

The last section in this book is not part of the PeBBu Thematic network. It discusses the energetic-environmental certification issue of urban lighting installations and contemplates partnering as an answer to procurement in performance based building. Finally, an analysis is given on the factors affecting the effectiveness of performance based standards in Singapore.

We hope this book finds interest among practitioners and researchers willing to implement and develop further the concept of performance based building.

Pekka Huovila
VTT - Technical Research Centre of Finland

Helsinki, June 2005

Section I

The PeBBu Network

The Performance Based Building Network: Impacts and Perspectives

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Abstract

This paper provides the background on the establishment and operation of the EU funded and CIBdf managed Performance Based Building (PeBBu) network. It gives an overview of the program, components, activities of the network so far. CIB has traditionally played a crucial role in the development of the performance concept and in its practical applications in the development of standards and regulatory requirements. With the establishment of the PeBBu project, the development of the performance concept has taken on a new dimension of practical approach and involvement of a large variety of stakeholders internationally.

Since its conception, the project has grown to include aligned activities such as two compendia projects and involvement with several CIB commissions. Extension into the Newly Associated States (NAS) countries and recent launch of the Australian network of PeBBu are examples of the fast spreading phenomenon of the performance approach. The PeBBu programme of work includes 6 scientific domains and several other tasks including PBB and CPD, PBB Decision making toolkits and CRISP Sustainability indicators.

The paper provides key lessons learnt from the experience of running the network programme. This is very useful for similar future endeavours that can learn from the PeBBu experience to succeed in hastening and widening the adoption of the performance approach in the building industry. These lessons include the dynamics of the various stakeholders in the building and construction sector for adoption of performance based principle. The lessons learnt are based on first hand experience of coordinating and managing the network and feedback from network participants.

The major accomplishments of this network such as expansion of the network and establishment of several aligned activities and strategic relations are also part of the paper. Activities and outputs that engage and benefit various stakeholders are described. There are still many hurdles to face and many challenges to encounter. This paper concludes with a perspective on the future of Performance Based Building in the times to come.

Keywords: Performance Based Building, Thematic Networks, performance approach/concept

1. Performance Based Building: an Overview

Performance Based Building is not a new concept! It has been practiced in some measure since ages even though it was not formally known as the performance approach. The earliest example of this can be found in the Hammurabi Code (c. 1950 to 1910 BC), which gave a dictum that a house should not collapse and kill anybody. This concept was also reflected in the early architectural philosophy of the Romans, as described in Vitruvius's De architectura libri decem (1^{st} century BC). Let us try to understand how we in the current times define the performance concept.

1.1 The Performance Concept

The process of designing, planning, coordinating and constructing a building involves an entire spectrum of building professionals who work cohesively together to address the needs of the client. However, this process is not so straightforward. Construction professionals, often new to each other, have to operate within unclear and dynamic processes and procedures. The way in which the building fulfils the expectations of all the stakeholders, including the providers, managers or occupants of the building, is increasingly becoming the measure of its success.

The design not only has to be buildable (in terms of cost and time), but stakeholders are increasingly enquiring about its maintainability, sustainability, accessibility, fire deterrent features, and its functional acoustic, energy and the performance. Each of these parameters has to satisfy a whole host of social, economic and legislative conditions. Traditionally, these conditions are governed by prescriptive codes and standards. Prescriptive standards are easy to understand and follow and the results are easy to monitor. However, their inherent inflexibility stifles innovation, leading to a poor match between true user requirements and the building, and poor value for money. By changing the focus from the input material's specifications (traditional, prescriptive approach) to the output user requirements (performance based) we will increase both the quality and the long-term value for money of our buildings. [1]

The performance based building (PBB) concept provides a flexible and technically non-prescriptive framework for building design and construction. The PBB approach enables greater innovation, aids international trade and cost reduction. Its application consists of translating human needs (functionality, comfort, etc) first into functional and then into technical performance requirements, implementing them within a regulatory framework and enabling the construction of buildings that provide long-term satisfactory performances. The Performance Based Building (PBB) concept applies itself to the constructed asset planning, programming, design, procurement and construction, life cycle management and operation, and to building regulation control. Although its definition is acutely debated, it is considered in broad terms as "*the practice of thinking and working in terms of **ends** rather than **means***". [2]

2. Establishment of the PeBBu Network

Recognising the relevance of the performance based building concepts for the building and construction sector of Europe, the PeBBu Thematic Network was established in 2001 and runs until September 2005 to further the knowledge, dissemination and application of the PBB concept worldwide. It is funded under the European Commission's (EU) 5th framework – Competitive and Sustainable Growth. Organisations from both EU and non-EU countries involved in PeBBu are research institutes; research funding organisations; universities; architectural and engineering offices; contractors; manufacturers; regulatory bodies, building and construction consultants, industry associations and governmental agencies.

2.1 Objectives of the PeBBu network

The main objective of the PeBBu Network is ***"Stimulation and pro-active facilitation of international dissemination and implementation of Performance Based Building in building and construction practice",*** and in that context to maximisation of the contribution to this by the international R&D community. [3]

The Network aims at combining fragmented knowledge in the area of Performance Based Building in order to build a systematic approach towards innovation of the building industry and applying user requirements throughout the building process. From this, white spots and a coherent future research agenda can be derived. End-users, policy makers, building industry and regulatory communities are closely involved in this development in order to facilitate dissemination and implementation of research results.

2.2 Components of the PeBBu Network

The PeBBu programme[1] includes the following "core" components (refer to Figure 1)

- International programming / coordination of research within 6 Scientific Domains.
- Involvement of target groups / stakeholders through three User Platforms for respectively a) Buildings Owners, Users and Managers, b) Building and Construction Industry and c) International Standardisation and Conformity Community.

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[1] More detailed information on the PeBBu Network, its program of activities and its organisation can be found in the designated PeBBu website at www.pebbu.nl. This website contains an online database with information on current PeBBu member organisations, all ±250 persons active in the various tasks, task description, meetings and publication; More information on the established Scientific Domains with downloadable PDF versions of recent Domain Reports; 1st International State of the Art Report on PBB; Newsletters; International Research Mapping Database.

- Four Regional Platforms in Europe to act as the bridge to and the initiator of aligned national activities (Northern, West/Central, East and Mediterranean).
- Network Management - Establishment of a Network Steering Committee, a Technical Committee and a Network Secretariat.
- Mapping of national and international research related to various aspects of Performance Based Building.

At the onset of PeBBu, the project began with 9 scientific domains[2]. These spanned across the various themes and aspects of performance based building. In the middle of the project, it was decided to terminate 3 of these domains (the domains on Built Environment, Organisation and Management, Information and Documentation) due to the vast scope of these domains, the lack of ongoing research and/or overlap with other domain work.

In addition to these core components, there are various aligned activities in support of PeBBu (Figure 1). These however, are not funded from the EU PeBBu budget. These aligned activities have been contributing to major achievements of the PeBBu Network. Meanwhile, in the first 2 years of PeBBu Programme, some other topics of interest relevant to PBB arose. These have now being developed as new tasks and are incorporated within the PeBBu workplan. The 3 new tasks are:

1. PBB & Construction Products Directive (CPD)
2. PBB Decision Making Tool-Kit
3. (CRISP) Sustainability Indicators for PBB.

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[2] Domain 1: **Life Performance of Construction Materials and Components,** investigates the performance of a material/component over its design life and predicts the service life, given the variables.
Domain 2: **Indoor Environments,** deals which the performance criteria and evaluation methods for healthy buildings.
Domain 3: **Design of Buildings** defines the user requirements in performance terms, implementation of knowledge and training needs for professionals.
Domain 4: **Built Environment** provides an interface between building and urban design.
Domain 5: **Organisation and Management** manages the design, construction, operation and maintenance of a building using the performance concept.
Domain 6: **Legal and Procurement Practices,** deals with legal issues of defining building quality in performance terms.
Domain 7: **Building Regulations** involves implementation of PBB regulatory systems & the role of national/international standards
Domain 8: **Innovation,** establishes connections between innovation building life cycle phases using comparisons with other more innovative industries.
Domain 9: **Information and Documentation** emphasises the new information requirements needed to support the performance based approach.

2.3 Key Achievements to Date

The PeBBu Network has made considerable progress in its first two years of operation. Some of the main achievements of the 1st two years of the existence of the Network are:

2.3.1 Successful operation as a Network

The foremost aim of the PeBBu project is to be operational as a Thematic Network. In that aspect, the network is a big success with the network in place and regular meetings held to strengthen this network.

2.3.2 Expansion of the Network

This entails the expansion of the Network to include several new countries from the Newly Associated States (NAS Countries). This ensures a complete European perspective for the stimulation and establishment of PBB practices. 13 new organisations from the NAS countries are now members of the PeBBu Network. Apart from this, several observer-members have become a part of the Network.

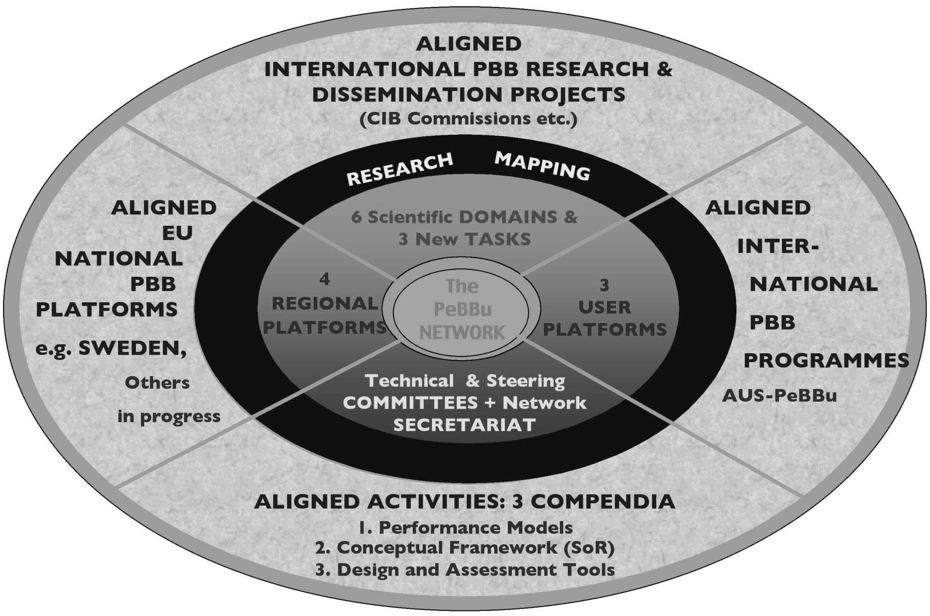

Figure 1: PeBBu Structure

2.3.3 Launch of Aus-PeBBu

An Australian version of the PeBBu Network has been launched in October 2003 in Australia. The Australian programme, referred to as Aus-PeBBu[3], is similar in structure to (EU)PeBBu.

[3] More information on Aus-PeBBu can be found on: www.auspebbu.org

With the launch of Aus-PeBBu, Australia is now able to participate in the global move towards the performance approach, which has occurred through regulatory changes from a prescriptive to a performance based building code. It is expected that Aus-PeBBu will expand to include countries in the Pacific Rim and South East Asia with which Australia and cooperation agreements in place (including New Zealand, China, Malaysia, Vietnam, Hong Kong, Singapore, Indonesia and India).

2.3.4 Establishment of aligned activities such as the PeBBu Compendia

The Compendium of PBB models developed a database that at present includes 30 such PBB models. PBB Compendium of Statements of Requirements aims for the development of a consensus based PBB conceptual framework and key-terminology. This has ultimately led to a consensus on PBB language, concepts and issues.

2.3.5 Production of the 1st International State of the Art Report

This gives an overview of the status off PBB in an international context. The International SotA analysis the spread of PBB principles through many National SotAs from the European context and a secondary research about proliferation of PBB principles in other parts of the world. [4] The International SotA has being published as a CIB publication and this is a good tool to disseminate vital information on PBB.

2.3.6 Establishment of many strategic relationships

Examples of these are:

1. Co-operation with ISO TAG8 (the ISO Technical Advisory Group that is responsible for building related standards) on a multi-year programme within ISO that aims for the production of performance based standards that are to replace or to be added to the current prescriptive ones.
2. Between PeBBu Domain 1: Life Performance of Construction Materials, Components and ISO. This relationship has influenced writing of standards related to durability of construction materials and components.
3. PeBBu has also established relationship with the E-CORE projects where PBB will be one of the main building blocks in a future European RTD strategy.
4. Co-operation with the Liaison Committee's of International Associations of Structural Engineering aiming for the establishment of a joint committee on PBB related pre-standardisation issues in the area of structural engineering.

2.3.7 Involvement with / and support of several CIB Commissions

Several CIB (Task Groups and Working) Commissions have been established to facilitate international exchange and co-operation in areas that cover aspects of PBB on a voluntary basis. As an average each such commission incorporates 50 appointed representatives of organisations worldwide who meet on a regular basis and aim for joint, voluntary, international R&D projects in their area.

3. Status of PBB

Over the last 50 years, there has been considerable development in the performance based approach. These developments have led to a clearer description of what the performance approach means in both concept and practice as well as its potential benefits and challenges [5]. These developments can be traced through the reports from the US Nationanl Bureau of Standards (1925, 1977), the proceedings of many conferences, and various CIB publications. [6]. Despite several leading programmes, implementation of the performance concept has been somewhat sporadic.

3.1 Status of PBB Domains

Although PBB is whole encompassing of the design, operation and maintenance of a building's lifecycle, under the PeBBu Network it has been divided into 9 (6 continuing) scientific domains to aid the investigation process. These domains span the complete lifecycle of a constructed facility - from the conceptual/ brief stage through to operation and maintenance (Figure 2). Moreover, they encroach on both soft and hard issues facing the design and construction process. The potential new activities of FM (facilities management) and education occupy definable "gaps" in the current PeBBu programme. This section summarises the state-of-the-art of the performance based approach in each of the 6 remaining domains of PeBBu and provides a brief future research agenda. [7]

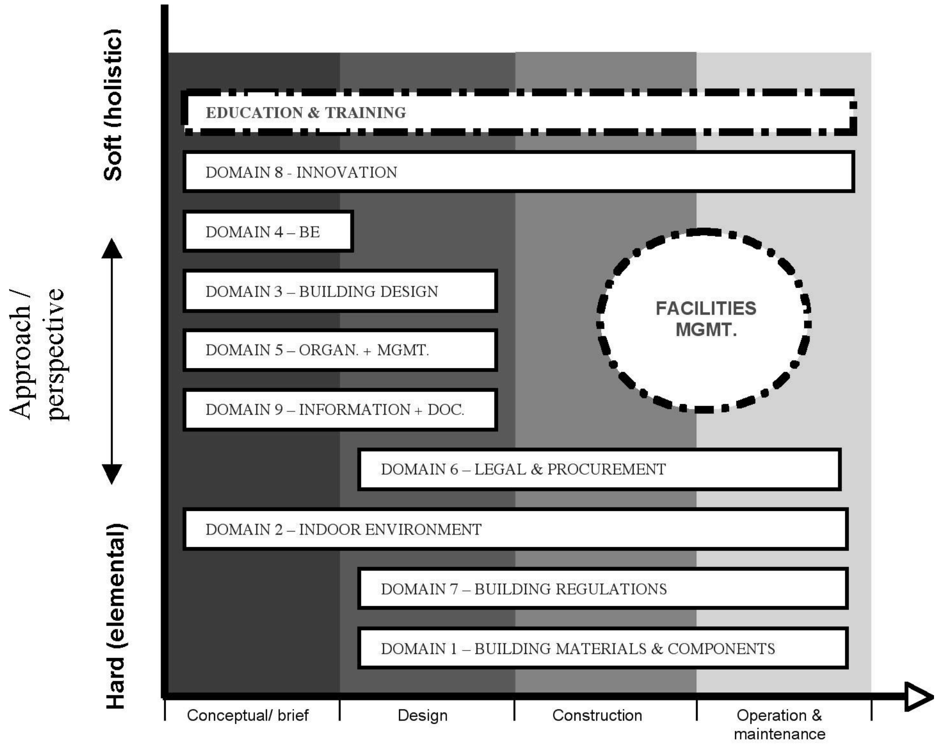

Figure 2: Domain Lifecycle Stages

3.1.1 Domain 1: Life Performance of Construction Materials and Components

The overall performance of a building relies on the performance of its materials and components. Therefore, how can the performance of materials and components be assessed in advanced to ensure the building performs as required? PeBBu domain 1 aims to address methods for predicting service life, particularly for novel building materials and components. Under PeBBu programme, this domain will further develop the Factor Method (system to estimate the service life when there is limited knowledge of long-term performance of components), develop an international suite of standards, and to design and prepare training sessions for both industrialists and academics.

3.1.2 Domain 2: Indoor Climate

This domain maintains that healthy buildings can be pursued by designers, constructors, building owners and building occupants, through the application of a number of qualitative and quantitative health-based criteria (methods, guidelines, protocols and tools to design, evaluate and measure the health status of buildings/ designs). The health of buildings in this context relates to air quality, ventilation, thermal comfort, noise and visual comfort. Although there is rich scientific literature and several experiences on the quality of the indoor environment, a uniform set of criteria across Europe or the world has not been defined. The majority of PBB implementation is isolated to different components and not in terms of the building as a whole. A general translation from subjective criteria to objective design parameters, and reverse when dealing with the evaluation, to a large part is still lacking. Research initiatives into the health and comfort of the building environment are ongoing. However, a lot of work is still required before PBB can completely replace current prescriptive buildings methods.

3.1.3 Domain 3: Design of Buildings

It has now become an economic necessity for the building industry to pay more attention to meeting user requirements. Therefore, there should be a focus on both the (technical) performance specifications for building parts, and on the management of (functional) user requirements and involvement during the building process. Thus, the problem of 'meeting with performance specifications' in the design stage of the building process should be addressed: -

5. The translation of client and user requirements into objective, measurable performance specifications.
6. Classifications and formats for performance specifications.
7. The testing of (preliminary) design results against agreed performance specifications.

PBB in the design of buildings has mainly been undertaken in research and education rather than practice. In several countries there are programmes aimed at structural changes in the building industry. Examples are ‘Rethinking Construction’ in the UK and the ‘Process and Systems Innovation Programme for the Building Industry’ (PSIB) in the Netherlands. The primary barrier for performance based design of buildings rests with the culture and existing fragmentation of the construction industry. In retrospect, linking performance based design with IT (product modelling systems), demonstrating its value in educational programmes and developing a universal language of specifications, could speed its adoption.

3.1.4 Domain 6: Legal and Procurement Practices

This domain focuses on the problems encountered towards PBB specifications via procurement and the legal issues that subsequently arise. There is currently no state-of-the-art that could be applied across the EU, rather a collection of national practices. There are two significant factors driving towards PBB, international and government influences. International influences have arisen from experiences of multi-national companies around the world and a desire to replicate best practice in other countries. Government influences have been founded on their responsibility for construction output, and that they need to maintain or increase output whilst at the same time reducing public sector expenditure. In order to reconcile these two forces, governments have increasingly turned to methods that involve private finance in projects. These methods include: Design and Build (D&B); Design Build Fund Operate (DBFO); Build Operate Transfer (BOT); Build Operate Own Transfer (BOOT); Private Finance Initiatives (PFIs); Public Private Partnership (PPP). Currently it is reported that in excess of 100 countries are procuring construction and engineering works under the generic heading of PFI. The majority of uncertainty lies with risk and liability, not least the issue of duty of care v duty of result. Both private and government influences have resulted in moves towards PBB since performance specification lies at the heart of both D&B and PFI philosophy.

3.1.5 Domain 7: Building Regulations

Innovation in construction is heavily dependant on the building regulatory system. In many countries, the system is based on what is termed a ‘prescriptive’ approach, where a single, or very few solutions are provided as ways to comply with building regulations. This has the effect of creating a design and construction industry that is restricted to designs that fit those specific solutions. Performance regulations, which focus on intended outcomes, are intended to encourage innovation and trade by expressing what regulations are intended to achieve. Many countries are moving in this direction or have already implemented PBB building regulations. However, there is very little research in the area of performance based regulatory system issues on a policy level. Research, in most cases, focuses on the technical solutions to the regulations. On a national level the Australian Building Codes Board has been fairly active in conducting research that relates to the building regulations. More specifically, Australia formed what is called the ‘Fire Code Reform Centre’ in 1994 to look at various issues relating to fire safety in an effort to improve the building code. Countries such as France and Canada also conduct similar research in various areas. In the United States, there has been some research in the area of risk and public policy as it relates to building regulations.

3.2 Domain 8: Innovation

The principal focus of PeBBu Domain 8 is to examine innovation through the ‘performance of buildings in use.’ Innovation is taken to concern the multifaceted value creating, capture and delivery role of buildings. This includes the building appropriately meeting the needs of the client system and of whole life cycle performance. Currently, there is a mass of technical, product-related criteria (principally from a top-down regulatory direction) that helps maintain a base-line standard of construction for health and safety purposes. This does not cover all areas of construction, such as the process of construction, or many aspects of the use of buildings and their impact on society. Both the EU Innovation Scorecard and the UK’s ‘Key performance indicators’ do not reflect any indicators in the area of innovation and learning. Nor do they focus on the client’s/ user’s needs. Performance metrics for innovation in PBB thus need to appropriately integrate building and business considerations. For the industry to succeed it needs to maintain a minimum level of innovation as a norm and this should be reflected in explicit innovation performance objectives for the various parts of the industry. The challenge for the domain will be to identify clear and realistic innovation objectives and measures, differentiated as appropriate by industry sector, which can make a real impact in practice. Part of this aspect will include consideration of the interactive roles of the various stakeholders running from materials suppliers, through builders merchants, designers, specialists and builders, to users and owners of the built facility.

4. Key Lessons from the PeBBu Network

The PeBBu project has provided the opportunity to engage a wide variety of stakeholders in moving towards the widespread application of the performance concept in building and construction. Some of the lessons learnt from running this project have been presented in this section. These are based on first hand observation and knowledge, and informal feedback from some network participants. The key lessons learnt are presented below:

1. **Importance of funding**: The benefits of the PBB concept are not always recognised by the industry to be of real and significant value and therefore, many critical stakeholders are hesitant to participate. The funding by the European Union of the project has proved to be a key push to the concept whereby several opportunities towards global and lasting promotion of the performance concept have emerged.

   The worldwide development and promotion of Performance Based Building has a much wider scope than the current scope of the PeBBu network. Much additional effort and in-kind contributions of time have been made by PeBBu participants to cover work that is not funded. Further funding of priority areas, which are not yet funded is therefore required. [8]

2. **Addressing fragmentation of the industry**: Fragmentation in the building exists at both the differing levels of expertise as well as working in different phases of a project (e.g. design phase vs. installing services phase). A rigid programme structuring is also likely to have similar fragmented effects. A more flexible programme of domains and tasks, which promotes maximum interaction and participation in various themes should be encouraged to remove barriers. An understanding of this prompted the movement from stand-alone meetings to organising series of meetings that promote greater interaction in the PeBBu project.

3. **Stress on value and benefits**: It is very important for a project like PeBBu with a strong research focus to identify and communicate the benefits and value of the application of PBB to the stakeholders. Producing such a statement of value and benefits should become a priority for the project.

4. **Necessity to engage the right stakeholders at a right time**: This implies that it is not necessary to involve all the stakeholders in all the phases of the project. Critical people who can easily become the stakeholders champions in the project need to be engaged at the outset.

5. **Effective communication and collaboration**: This is a practical lesson from the PeBBu network that brings forth the need to facilitate collaboration through effective communication. Despite the developments in the IT sector where electronic communications have taken over the majority of meetings, it was realised in the course of the project that face-to-face meetings were essential to the operation of the network. Similarly there is a need to communicate the right message in the best possible way to the right stakeholders!

5. FUTURE CHALLENGES & MAIN PRIORITIES

Performance based regulations and practices are currently both mandatory and voluntary. Culture and a lack of resources have somewhat prohibited the regulation bodies to fully ‘prescribe’ PBB practices. PBB must be contextualised to suit a particular country and lessons learnt from other PBB applications must be reviewed and adapted to differences in government, culture, and economy. Successful application of PBB requires the development of new knowledge, understanding and PBB tools.

Prescriptive-based building sometimes works well in simple deemed-to-satisfy buildings, thus, the application of PBB principles is not always necessary. Therefore, the two approaches should work in harmony: the performance approach should be available to those who require more complex innovative developments or design concepts driven by stakeholder requirements.

In order to obtain the maximum benefits of PBB, the following needs to be delivered: -

1. Actions to progressively align organisations business processes to PBB
2. Education and training regarding the appropriate circumstances for using PBB
3. The steady increase of the performance criteria captured within PBB

Other framework issues that need to be addressed to support the PBB concept include public policy, regulations, innovation (in various fields such as materials, building technology, design and construction process etc.). In particular, developing assessment methods that verify the approach to support the regulators, methods that allow the client to ensure that their performance requirement is actually delivered, and guidance of how to include PBB in an organisation’s business strategy are crucial for the assurance of both the client and construction professionals.

The PeBBu project expects a further increase in stakeholder involvement in various aspects of PBB. However, specific methods need to be explored to engage effectively the critical stakeholders that can help hasten and broaden the adoption of the performance concept. One of the main challenges lying ahead of the project is to identify clear value and benefits of the Performance approach for various stakeholder groups, substantiated with real case studies, and to package them for a compelling presentation. This will ultimately facilitate client- or demand-driven innovation, made possible by the performance approach.

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Life performance and innovation on construction materials and components

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Abstract

PeBBu domain 1 on life performance of construction materials and components is part of the EU financed thematic network on Performance based Building. Domain 1 addresses issues in a thematic field, where performance based building, service life, life performance and environmental declaration of products draw attention to each other. As can be seen in the recent development of international standards, service life and performance requirements gain a significant position as part of sustainability assertions of buildings and building products. Domain 1 aims to identify aspects of practical application of the ISO standards series 15686 on service life planning, as these standards provide the methodological basis to identify service life, and to provide the market with service life information. As service life per se relates to performance requirements and performance over time, and as sustainability in building construction related to fitness for purpose, performance based building fulfils a central hot-spot of concern in relation to building sustainability.

D1 addresses stakeholders' concerns when involving service life – both concerning the provision of information as the adaptation of information to a specific building design. Hence, concerns of manufacturers as well as designers and other relevant stakeholders are dealt with. Issues of concern for further R&D as well as feedback and input to ongoing international standardisation, are identified by D1. With the direct link to the durability and service life research community and the involved standardisation bodies, the thematic network can play an important role in promoting performance based building.

Keywords: Virtual enterprise, information exchange, information systems, distributed engineering

1. Introduction

PeBBu is a thematic network, funded under the European Commission's 5th framework addressing competitive and sustainable growth. The Performance-based building network was initiated in October 2001 and will be running through to September 2005. One of the main reasons to establish the network was to facilitate and enhance the existing performance-based building research and activities by networking with the main European and international stakeholders. The creation of a network that is supposed to utilize synergy-effects well beyond the termination of EU funding is the main aim. Involved are currently more than 60 organisations worldwide.

Currently ongoing international standardisation projects, both on ISO (ISO/TC59/SC17) and CEN (CEN BT/WG174) level set environmental declaration of building products into the context of sustainability assertions ("sustainable building" in ISO and "integrated environmental performance of buildings in CEN"). In that context, it is of outmost importance to address the entire life cycle of the product, per se or as part of a larger functional component or ultimately the building. This in turn requires information about all relevant stages of the life cycle, including predictions or estimations of service life aspects. First based on a reasonable understanding of the post production life cycle stages, an identification of processes occurring during the life cycle can be made, and hence first then, such scenarios and their associated environmental impacts or sustainability aspects can be identified and included in declarations. Where these developing international standards are relating to service life, they may take benefit from the establishment of standards or standardised routines for the declaration of service life of products. Meanwhile, it must be obviously clear, that for a manifold of products used in building construction, an expression of service life appears meaningless to establish. Examples for this are ancillary products as well as generic products that are produced and supplied without any knowledge about their application. Examples are cement / concrete, construction wood, etc. For other mass products, such as screws and nails, the link between exposure environment and product choice may be so obvious, that a service life declaration is not needed in practice. A declaration of service life information for products is intended to enable stakeholders, like e.g. the designer or the investor, to take decisions among product options, and to enable the methodology of service life planning to be operational, with all its potential applications and benefits.

Assessment of service life, and declaration of service life, may follow a three-step sequence, along:

- A description of product properties
- An analysis of the durability of a product under certain conditions
- A testing-based or estimation-based expression of service life of a product under given conditions

In order to identify the current status of service life consideration in the construction sector, and in order to inform about the ongoing work, PeBBu D1 has established enquiries among material producers and building consultancies. The goal is to identify to what extent the ISO standards are known and applied throughout industries, or whether and on what basis claims relating to service life of products are being made. Preliminary findings from the enquiries directed to manufacturers allow the conclusion that the industries in general are aware of the market relevance of service life information, and that many manufacturers are ready to provide information, or have started consideration of service life aspects of their products. In general, service life information is not yet systematically provided to the market, as well as it is not yet demanded either, but the actors appear to be able to provide and handle such information within reasonable time frames. A rising demand for service life declaration formats can therefore be foreseen. Ultimately, the demand for service life information will raise due to the attention the issue receives in international standards related to sustainability. In order to allow the industries to supply the market with service life information, a clear demand for harmonized rules on how to declare service life can already be detected.

2. Introduction

The international council for research and innovation in building and construction (CIB) began work on the subject of building performance in the 1970es. The "performance approach" was described as "first and foremost, the practice of thinking and working in terms of ends rather than means. It is concerned with what a building is required to do, and not with prescribing how is it to be constructed" [4]. Over the years, CIB has started numerous working groups addressing performance-based building; among these the thematic network PeBBu, being a thematic network addressing performance-based building in 6 scientific domains, 4 regional platforms and 3 user platforms.

The six scientific domains are:

1. Life Performance of Construction Materials and Components
2. Indoor Environment
3. Design of Buildings
4. *(Built Environment) cancelled*
5. *(Organisation and Management) cancelled*
6. Legal and Procurement Practices
7. Regulations
8. Innovation
9. *(Information and Documentation) cancelled*

Even though domains 4, 5 and 9 have been cancelled, domain reports as well as an international R&D agenda will be produced.

Domain 1 on life performance of construction materials and components draws its rationale from the fact that the overall performance of a building relies on the performance of its materials and components. While performance aspects of materials, components, and systems cannot sufficiently and entirely describe building performance, evidently the assessment of material and component performance is a necessity to ensure the building performs as required. Domain 1 has been established to focus on methods for predicting the service life of construction materials and components.

As service life and life performance information may be based on experience and with that may be available for materials that long since have been applied and / or tested, for new and innovative materials, such information is not available for obvious reasons, but ever so needed for application in performance based building. Hence, a method for *estimation* of service life is needed. The ISO standard series 15686 addresses service life planning of buildings and constructed assets. This standard series also provides a method for estimation of service life, and the PeBBU domain 1, with its focus on life performance of construction materials, components and systems specifically relates to these standards. Domain 1 intends to exemplify these standards with the goal to enable wider provision of information needed for the process, as well as enabling a wider application of service life information in project planning and building design.

While focussing building materials and components, the context of functional application of materials and components deserves consideration. Consequently, D1 also addresses systems. An example for the reporting of D1 is given in the French state of the art report on the performance approach [7].

3. Performance approach as key element in sustainable construction

Application of the performance approach has recently led to the establishment of performance based building regulation, see for instance [8] and the New Zealand Building Codes [9]. Another driver for the application of a performance approach in building construction are “Public-Private-Procurement” (PPP) contracts, which are a growing trend in numerous countries. While earlier public institutions generally became the owner of works as delivered by industry, they automatically assumed the induced costs of a bad prediction of the service life. With PPP, they are now contracting with companies which will build and manage a works for a beforehand agreed number of years: for their own interest, these companies will then try to get better control on the service life of the works, and ask commitments from the product manufacturers. [10].

Additionally, there also is an obvious role of performance based building in the context of sustainable construction. As the performance approach starts off with an expression of what is expected from a building, in terms of functionality, the identification of performance requirements can perform as an anchor in other elements of sustainable construction. Based on durability assertions, service life planning can assist in the identification of reasonable scenarios for the service life and for the development of performance over time. As the service life is defined as ending when the building or parts thereof no longer meet or exceed established performance requirements, these requirements turn significant for the description of the building or product life cycle. Additionally, the performance requirements help to identify processes employed during the use phase. These in turn are needed in order to establish environmental declarations and to enable life cycle cost calculations that do consider the entire life cycle. As the identification of scenarios and processes is depending on the current application context and user requirements as well as to the development of performance over time, this means that the declarations and life cycle calculations depart from default scenarios and consequently reflect a building specific situation. While a building specific consideration enables decision takers to tailor the information underlying decision making to the developing design, it must be noted that due to this adaptation, the generated declarations and assessment results may loose their validity for generic interpretation [11][12].

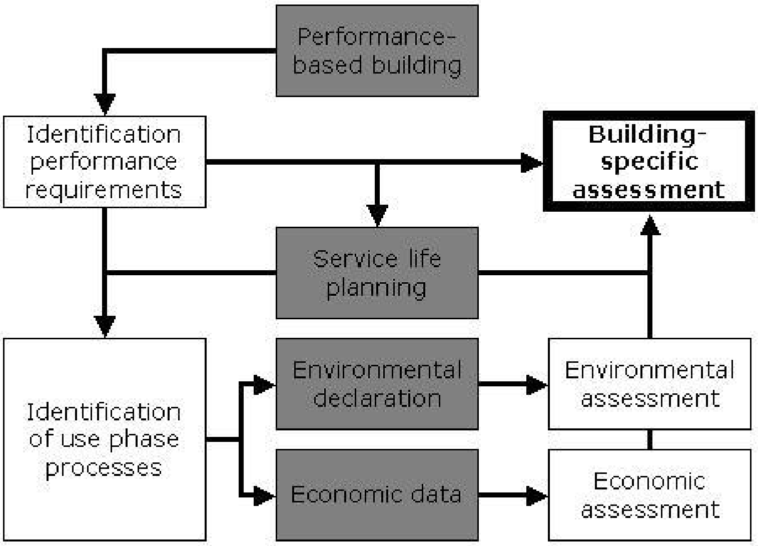

Figure 1: Performance based building and service life planning as central elements of sustainable building [13].

4. Link to Environmental Assessment / Sustainability Assertions

Where the topic of sustainable construction on one hand provides the contextual frame and the philosophical reason for acting on the topic of service life, the methodologies developed to identify reference service lives and estimated service lives, also in terms of service life declarations, provide input to in especially environmental product declarations of building materials and components, and equally evident, to the assessment of environmental performance of buildings, both items addressed in ISO/TC59/SC17 and in CEN/BT WG 174.

These international standardisation projects also identified, similar to the content of figure 2 below, that the assessment of environmental performance of a building goes well beyond the aggregation of product level information. The performance of products throughout their use phase as part of the assessed building becomes a key point of interest.

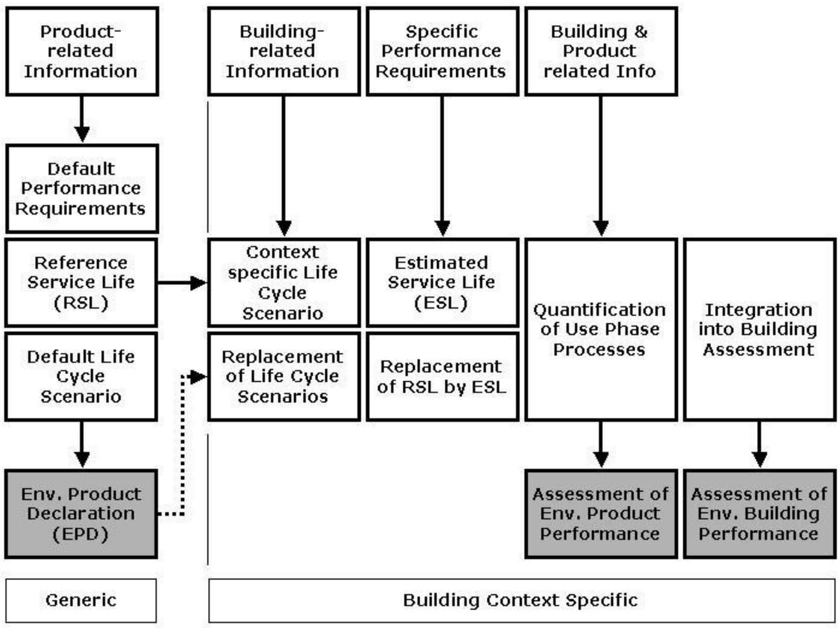

Fig 2 – the route from product information to assessment of building performance [14].

The consideration of product performance as an element of building performance, and the recognition that a correct description of a product life cycle often is not possible isolated from an inclusion of the building in which the product actually is performing, leads to the necessity to identify the functional context of a product, component or system. This context on the one hand requires performance from its parts, while each part may provide preconditions of functionality and performance to other parts, or the entity. At the same time, performance requirements as expressed by users and other stakeholders, may concern the entire building, or may be directed to specific elements of performance. This inter-dependency of performance in a building context can be illustrated as in figure 3 below.

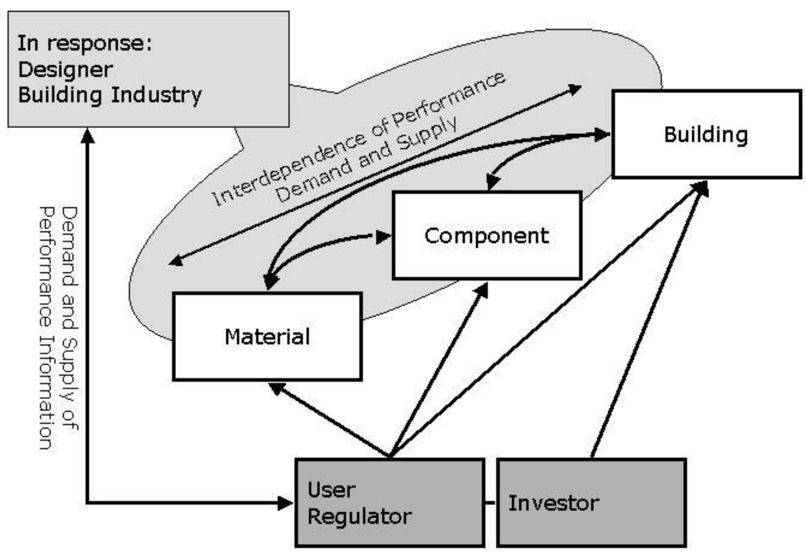

Fig 3 – Dependence of performance of products, components and buildings [15].

5. Modelling Durability and Life Performance – PeBBu D1

PeBBu domain 1 ‘life performance of materials and components’ has as one of its main objectives to further develop the methodologies contained in the ISO 15686 standards series in order to bring the concepts closer to practical application. The demand for this objective stems from the situation, where product manufacturers are willing to provide environmental declarations about their products, and where they also are generally willing to provide information about durability and long time performance of their products. They can however not be made responsible to provide the market with information on durability and performance for situations that are highly specific. In other words, manufacturers can only provide information valid for a small selection of situations that correspond to the main purpose of their products, and that reflect a small selection of conditions in which their products are applied. These restrictions refer both to the application of the product, the integration into a building, the product wear due to use, the exposure to environmental degradation, climatic situation etc.

For situations, where the actual product application, or the specific use conditions do not coincide with the expectations the manufacturer had in mind when providing information, this information may not be valid. In cases of extreme deviation, the information may even be considered as irrelevant. Ultimately, the manufacturer can neither be held responsible for provided information.

Still, designers and other stakeholders have to make decisions related to the integration of products into a building design, or related to the expression of performance requirements, be it in the clients brief or in performance based regulation. The expression of reasonable performance requirements relies on competent and well informed bodies establishing these requirements. “Classification of stakeholders as demand and supply sides is a convenient simplification. However, in reality the industry cannot be so easily categorized as consisting of these two sides. In some instances, some stakeholders can be on both sides (e.g. a developer), and in other instances can be on either side. Since the performance approach is mostly about fulfilling the desired “ends” of the demand side, any project that involves educated and innovative stakeholders on the demand side and well-equipped stakeholders on the supply side has a much higher possibility of success.” [16]

D1 strives to identify the knowledge-demand of relevant stakeholders and to equip them with information so that they each can adopt their behaviour on the product- and building-related “information market” to the demands arising from an application of the performance approach. Concerning life performance of materials and components, this means that the suppliers of information must deliver information that reflects well established “main stream” scenarios for the life cycles of their products, rather than the most beneficial case, while providing information in transparent means, that enable the user of information to identify, analyse, and where necessary adapt and replace parts of the information provided.

For this, the user of information must be equipped with sufficient knowledge about scenarios and their validity as well as their significance for provided information. Further, they must be enabled to identify when scenarios need adaptation of replacement in combination with information about other scenarios and associated data.

When a designer of a building, or another relevant stakeholder, detects that the basis on which declarations have been provided does not sufficiently coincide with the application in the planned building, the designer appears to be the only reasonable initiator of the adaptation process. This does not mean that he has to perform the process, but it will have to be performed as part of his initiative and responsibility. The process to adapt declarations from a generic to a case specific context is illustrated in figure 4 below, where additionally, the spheres of responsibility are indicated. Even where the information is modified, the starting point has still been the information contained in the RSL, meaning also the adapted declaration / assessment is based on manufacturer information.

As product manufacturers are the primary source for product information, they may provide the market with life cycle and service life information based on the reference service life, as established in ISO 15686-1 [17]. Based on enquiries cast to manufacturers, it can be said, that a large share of manufacturers is addressing the issue of durability and service life of their products. Not all are aware of the ISO standards, however. The procedures of addressing service life and durability are different between companies, likewise the communication of such information to the market. Where some manufacturers provide information, others appear to rather use information for internal purposes in product development. Currently, the variety of approaches to the issue of service life appears to create some doubts as to the value of provided information. While different approaches all may have their justifiable fields of application, there is an evident demand arising for guidance and harmonization, especially in a situation, where forthcoming standards are relying on information about service life, [6] For these standards to succeed, there is an evident demand for the establishment of a common basis for identification and communication of service life information.

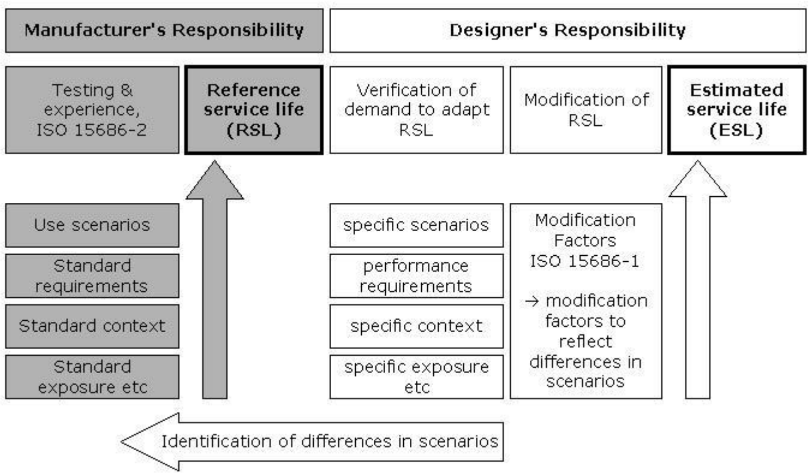

Fig 4 – The role of manufacturers and designers concerning determination of RSL and ESL [14].

Manufacturers appear to a certain extent reluctant to provide data on reference service life of their products, claiming that the service life of a product depends not only on the quality of the product itself, but as well on the way it is installed in the building, the conditions of use and the care with which it is maintained. Therefore, it may be realistic to think about a more open way to communicate information and data on service life. Two tools have been developed in CSTB for addressing that point: data fusion and Failure Mode and Effect Analysis (FMEA), where data fusion [18] can be applied for an exhaustive compilation of various heterogeneous data available on the service life of a product (test results, expert advices, field data, manufacturer assumptions), and FMEA [19] for anticipating the different ways a product may fail, and for drawing event graphs to illustrate it.

Such a set of data, more explicit and transparent than only a number for service life expectation, may cause less resistance for manufacturers to provide, and may be more open for designers to adapt to their actual project.

6. Conclusions

Innovation in the building sector may be described as either supply-driven or demand-driven. In the first case, the provider of innovative solutions will seek to convince key market actors to recognize and apply the innovative products, in the latter case, the suppliers of products are to develop solutions that meet the requirements originating from the innovation demand. In both cases the communication of life performance, or service life, aspects is an essential element of information. For innovative solutions, which in many cases are new developments rather than adaptations of existing solutions, no information on long-term performance and service life will be available. Such information hence must be estimated, e.g. in accordance to the EOTA guidelines and the ISO 15686 standards.

Where service life information is communicated between various stakeholders of he building sector, it has to be assured, that a common understanding, also of the underlying scenarios for which information has been provided, as well is communicated and understood by all parties participating in the communication. A harmonized approach to service life declaration may be very helpful.

PeBBu D1 aims to investigate to what extent actors in building construction already today are informed about the ISO standards, to what extend they make use of service life information and apply the performance based building concept. A general conclusion is that the concepts appear to be well known, but there still is a significant lack of experience and feedback form examples, where the concepts have been applied systematically and successfully. However, the availability of information and the number of examples of application is rising, all while the development of tools for the application of service life planning has taken up momentum. From this, in combination with the general awareness of the usefulness of the concepts of performance based building and service life planning, it can be assumed that the development of tools, and the integration into standards relating to building sustainability, will spur the application of the concepts.

The communication of service life information within the construction sector sets high requirements concerning transparency of the information. A declaration of service life can only reflect one or a few scenarios for product application. Therefore, designers for instance, may need to perform or initiate a process of modification of declared information, all in order to obtain information that is relevant to the situation in a specific building context. The primary source of information will still be the manufacturers, while recognizing that information provided by them only can be based on reference scenarios. Such scenarios must be available for scrutiny by those applying the provided information.

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Performance Based Building and its application to Healthy Buildings

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Abstract

The European funded Project PeBBu, Performance Based Building, is a Thematic network under the Competitive and Sustainable Growth program, which started September 1st, 2001 and will run for 4 years. In one of the domains of PeBBu, the domain Indoor Environment, a state-of-the-art on the Performance Based Building (PBB) approach with respect to healthy buildings is prepared.

The state-of-the-art on performance criteria for healthy buildings deals with current available methods, guidelines, protocols and tools to design, evaluate and measure the health status of buildings or designs for buildings. The health of buildings in this context relates to: air quality, ventilation, thermal comfort, noise and visual comfort. The work furthermore presents a framework in which the state-of-the-art and future research in this area can be positioned.

After a short introduction into PBB and its definition, this paper will summarize the state-of-the-art with respect to performance and healthy buildings, i.e. the results from the work of this domain within the PeBBu Network. With the developed framework as a base, different points of departure are chosen to indicate the status of performance based building: the building point-of-view and the environmental attributes point-of-view.

The main conclusion is that the PBB-approach already has a basis in the building process, but that some specific topics are lacking that currently impede the further integration of PBB. Indoor environmental attributes appear specifically suited for the PBB-approach and some interesting initiatives of performance based approaches for healthy building are ongoing or have been developed in recent years. Nevertheless, a lot of work still is required before PBB can completely replace the current prescriptive building methods, if possible at all.

Keywords: performance based building, indoor environment, healthy building, thematic network

1. Introduction

1.1 Performance Based Building

Performance is a concept that has gained increasing attention over the last couple of decades. In 1982 CIB [1] already presented statements that define performance for the building industry:

- The performance approach is thinking and working in terms of ends rather than means.
- Performance is concerned with what a building or building product is required to do and not with prescribing how it is to be constructed.
- A design solution, traditional or novel, will always need a quantitative base for testing and evaluation of its performance.

Initiated by CIB, PeBBu is a Thematic Network under the EU-Competitive and Sustainable Growth program. It started in 2001 and runs for 4 years. The overall objective is to stimulate and pro-actively facilitate the international dissemination and implementation of performance based building (PBB) in the building and construction practice. It is not intended to present the ultimate solution for PBB, but to allow for a more fundamentally motivated and integrated continuation of the further development of PBB.

The PeBBu-project has been divided in nine domains for which the PBB approach should be investigated. The here described work deals with the 2nd Domain: Indoor Environment. The intention of this domain is based on the believe that the achievement of healthy buildings can be pursued by designers, constructors, building owners and building occupants, through the application of qualitative and quantitative health-based criteria. From the occupant point-of-view, the ideal situation is an indoor environment that satisfies all occupants (i.e. they have no complaints) and does not unnecessarily increase the risk or severity of illness or injury. This environment is directly related to attributes as:

- *air quality*: health and comfort related to sensory, chemical and toxicological effects of compounds in the air,…
- *ventilation*: fresh air rate, re-circulation, efficiency,…
- *thermal comfort*: temperature, air velocity, humidity,…
- *noise*: noise from outside, indoors, vibrations,...
- *visual comfort*: view, illuminance, luminance ratios, reflection,…

Although there is a rich scientific literature and several national experiences on this subject, a uniform set of criteria across the European countries has not yet been defined. In PeBBu one of the objectives for the Indoor Environment domain is to deliver a state-of-the-art report on existing performance criteria for healthy buildings.

1.2 Definition

The concept of PBB and its methodology have been described in CIB-Report 64 in 1982 [1]. In the report of Foliente et al. [2] the state-of-the-art on PBB is updated. These two documents form the line of thinking that has been aimed for within the domain. In literature one can find a large amount of information on PBB and on performance criteria, but also a lot of different definitions. Foliente et al. [2] already noted that "first and foremost, a clear definition of the performance-based concept is needed and agreed on".

A definition of performance is context based. With respect to buildings, examples of contexts are the stakeholder, the building phase or a building object. E.g., with respect to the stakeholder, the user will have very different performance requirements than the contractor. The user wants to live comfortably in the building, whereas the contractor is interested in the performance of individual building objects to obey to the design plan. In the end of course everyone is interested in the total performance, in the building process this is not necessarily the case. This also means that PBB does not end with the completion of the building. Performance during the building life is considered just as important. Performance therefore is also a function of time.

With PBB the initiator does not have to deal with the indoor air temperature or the insulation thickness. He just can identify that he would like it to be comfortable under given specific conditions and/or that he wants the building to be energy efficient and healthy. In the design process then however translation rules are required to convert this subjective information into objective design rules and to define evaluation procedures. Translation and evaluation procedures are found in, e.g. legislation, rules of thumb and more sophisticated tools as modeling and case/knowledge based reasoning.

The above described definition of performance in the building process has been visualized in Figure 1. It has been compared to the non-performance approach. The performance approach part of the figure was adapted from Huovila and Leinonen [3] and originates from illustrations by the Dutch Government Building Agency. The total figure was developed and agreed on during the 1st PeBBu Domain 2 Workshop and the NAS Workshop [4].

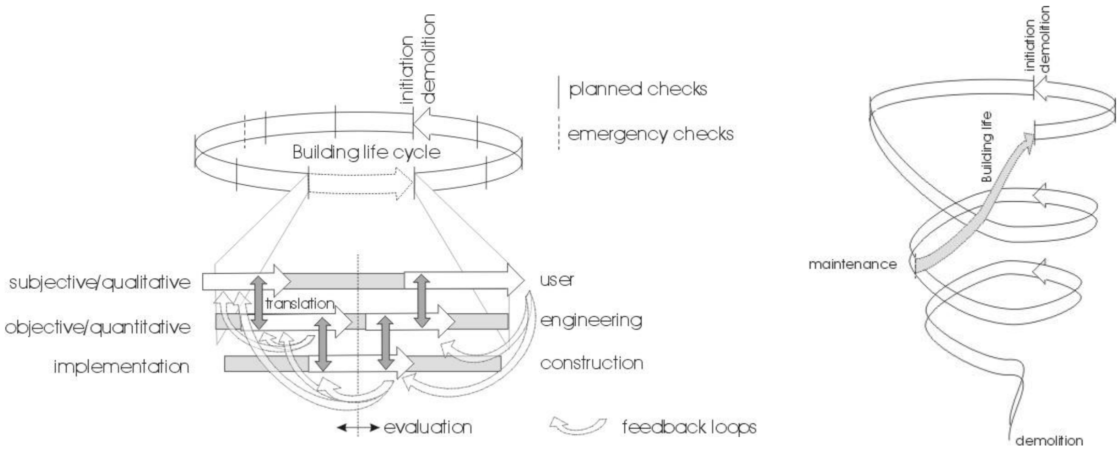

Figure 1: Performance based [left]versus a non-performance [right] approach.

The idea for the non-PBB approach is that maintenance is performed at a point of time of the building life when problems already have arisen and extra costs are required to correct the situation. With the PBB-approach the performance of the building should stay at its desired performance level throughout the building lifetime, and this is checked regularly. The zoomed out process for a specific change in the user requirements is similar for other required (performance) changes during the building life and is also the same for the initiation, design and construction of the building. Feedback loops are introduced to indicate the evaluation process that is an important part of the performance based approach.

1.3 Framework

Given the number of performance definitions and the different contexts that can be found, it is difficult to keep track on all the building performance information that is available. This also accounts for all the translation rules that can be derived. Therefore a system should be developed that allows a logical structuring of all the information related to performance based building, but also may improve the applicability of the PBB-approach. Obviously we are looking for a framework in which we can fit the PBB-approach and the available information in a logical and unambiguous way.

Several parameters should be incorporated in the framework. The most important parameter is the performance requirements that are set by the stakeholders. Furthermore, the point of time in the building process will determine the type of requirements that are set. This will be closely related to the building phases that can be identified. Finally, the actual building performance is of interest. This parameter has a close relation with the building objects.

Interrelations between the building phase and the type of stakeholder are obvious, as is the case for building objects and building phase. Each specific performance criterion therefore can be related to the individual contexts. By presenting these contexts on axes in a three-dimensional format a matrix is developed that facilitates the performance-based matrix. This approach has been derived from the work of Mallory-Hill [5] and can also be found, though in a different context, in Foliente et al. [2].

The framework is visualized in Figure 2. The matrix approach presents a database that allows filtering to come up with the specific performance requirements that relate to a specific building phase or stakeholder. It may also relate to a specific environmental attribute X or Y that is addressed differently (i.e. different target values and evaluation methods) at different points in the building process.

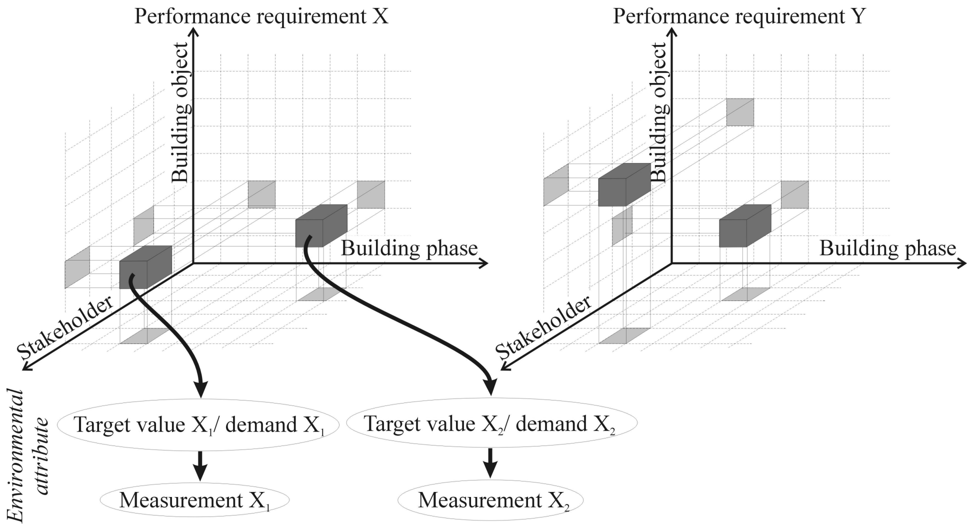

Figure 2: The Performance-Based Matrix.

2. State-of-the-Art

The above presented definition of PBB and the developed framework were required to come up with a state-of-the-art on PBB, and PBB and the Indoor Environment in particular. This state-of-the-art in the PeBBu project is derived through a literature study and a study of ongoing research in combination with input from the participants in the network. This is an ongoing process given the enormous amount of work that already has been devoted to PBB.

The intention also was to organize and categorize this information, in order to identify gaps in the PBB-information. That is why the state-of-the-art has been summarized according to the different axis of the framework in Figure 2. A database structure has been developed for this. For a categorization to the indoor environment the attributes as Air quality, Ventilation, Indoor climate, Acoustics and Lighting have been used. Assuming that the framework/database can be filled with information derived from literature and ongoing research, it eventually should be possible to identify the gaps in the matrix. These gaps should be valued and commented on and it should be determined whether they require additional research. This presents the goal of the PeBBu-project. Of course, available references may fit well in the eventual future PBB framework, e.g., as a reference to a target value or an evaluation procedure, or as a translation technique.

Summarizing the information that has been gathered from the literature research thus far, and assuming the above described context based performance approach, one can conclude that a lot of information on PBB is already available. However, most of this information deals with isolated topics and lacks the connection to the larger point-of-view. For example, with respect to materials (e.g., material emission) and some individual building objects (e.g., energy performance) the performance thinking is well established. Though differences between EU-countries are obvious, with at a first stage focus on the energy performance and in a second phase on, e.g., material emission. Furthermore, focus has mainly been put on the separate (building) phases and not on the translation between higher level performance requirements and lower level implications (see Figure 1 [left]). A general translation, beyond the traditional solutions, from subjective criteria to objective design parameters, and reverse when dealing with the evaluation, to a large part is still lacking. This hampers innovative developments, which forms one of the important drivers for the application of the performance based approach. Individual initiatives on several aspects however can be found. The coupling of these initiatives and the generalization appear to be important research areas for PBB. The Indoor Environment domain is one of the domains within PeBBu for which the translation from subjective to objective information is a key-item.

Some interesting examples of PBB and the Indoor Environment already can be found. For example, the Government Building Agency in the Netherlands presents a progressive approach with respect to the application of PBB. It builds on developments in the Dutch Building Decree [6]. The integral quality of buildings that are designed by the Agency is captured through the use of performance specifications. Indoor environmental attributes form an important part of these requirements. The performance specifications for building environmental attributes are presented in a subjective manner that fits in with the brief phase. Translation into the next phases, as visualized in Figure 1, is partly made by referring to, e.g., rules of thumb and guidelines. On the other hand for some attributes values are prescribed that restrict the freedom of design. So the trade-off between performance and prescriptive based values is still under discussion. Regulations currently restrict the unprecedented use of the performance approach in the design phase. On the other hand, the equivalence principle that is introduced in the Dutch Building Decree allows for new developments. From the literature study it appears that the Government Building Agency presents the state-of-the-art with respect to PBB as currently implemented in the actual building process. Note that this only applies to the first phases of the building process.

A different approach with regard to PBB has been developed by the Finnish Society of Indoor Air Quality and Climate (FiSIAQ). They have combined specific performance criteria in order to come up with a classification of the indoor climate [7]. The classification deals amongst others with target and design values for thermal conditions and the indoor air quality, with criteria for construction cleanliness and moisture control and criteria for material emissions and clean HVAC components. For these topics a categorization is proposed from which target values and material use are derived including general verification procedures. The classification affects the design as well as the construction phase. For the latter, categories are determined that rank the construction cleanliness. For building materials classification labels have been developed that objectively qualify a building product. In general, the highest classification for construction and building materials is required to obtain the highest classification for the indoor climate. This classification is in action in Finland since 1995 and has been developed further since then. The FiSIAQ-classification is voluntary, but currently it is a code of practice to apply this classification of the indoor climate, especially when it is used for marketing purposes. Developments in the building industry, e.g. labeling of materials and cleanliness of HVAC systems, are adapted to this procedure. The significant reduction in material emission that has been achieved through the introduction of the material label indicates the possibilities of the PB-approach.

The above two examples relate performance thinking mainly to the design and construction phase. The user phase nevertheless is just as important. This is where the ASTM Standards on whole building functionality and serviceability may be applied [8]. This evaluation procedure captures the quality, i.e. the performance, of a building by comparing the present-day requirements set by the occupant with a rating of the facility. To a large part relative objective descriptions are given to perform this comparison. This is one of the several examples of serviceability rating, as a part of the post occupancy evaluation, that are available and applied in practice.

In [4] approximately 30 other approaches that are performance-based have been categorized to the building phase(s) in which they can be applied. Such a categorization has also been made for the other axis of the framework, i.e. stakeholders and the building objects. From this categorization one can conclude that the (limited) translation between building phases as found in the approach by the Dutch Government Building Agency and FiSIAQ are relatively scarce. An important question of course is how this translation should be determined. In this respect interesting initiatives on PBB, that specifically deal with indoor environmental attributes, present possible solutions. These initiatives try, e.g., to translate complex material properties in low-level user friendly performance characteristics [9] or present design decision support in the early design phase to adhere the design to desired performance requirements [10].

With respect to health and comfort we can find several initiatives on defining performance criteria and translating them into design solutions. In the EU 5th FW Project HOPE (Health Optimisation Protocol for Energy-Efficient Buildings) a procedure has been develop to determine the health and energy performance of existing office and apartment buildings [11]. Recently also the ISIAQ-CIB TG42 Guideline on Performance Criteria of Buildings for Health and Comfort has been published [12]. In this guideline performance criteria and design information has been gathered to design healthy buildings. The guideline has been developed from the information that has become available from, amongst others, the HOPE-project and from the FiSIAQ approach as described above. These references present the state-of-the-art with respect to performance and healthy buildings.

3. Practical application

Performance-Based Building over the last two decades has found itself a basis in the building design, construction and use. The main difficulty with the term performance is that its scope has become so broad that different definitions are used. In principle the difference in definition is not problematic as they often refer to different parts of the building process. This means that the definitions for performance to a large part are context-based.

An important step in the development of PBB must be the unambiguous definition of performance in the different phases of a building life. Figure 1 visualizes the possible steps in the building life that can be distinguished (initiation-brief, design, construction, use, renovation-demolition). As indicated in the figure and in the text, in between these steps it often will be necessary to perform some kind of translation in order to deal with the performance criteria in the next step. In Table 1 the different performance definitions in the different steps are summarized. The Indoor Environment Domain of the PeBBu-project can be found in all steps (phases) of the building life and adheres to the performance context described in Table 1. This makes the indoor environment one of the more important topics in relation to performance-based building.

Table 1. Short description of the different context in which performance is used throughout the building life.

Steps	Performance context
Initiation-Brief	Functional and (qualitative) performance requirements as defined by the investor/owner.
Translation	Link qualitative requirements to quantitative (performance) criteria and define evaluation methods (e.g. conditions for evaluation) or otherwise determine other objective evaluation methods.
Design	Quantify the requirements/performance criteria either through the evaluation of the design via tools or by applying expert/knowledge-based or other objective information that enables the evaluation as agreed on.
Translation	From the design process the importance of performance requirements for the construction process and material use should be indicated, including evaluation procedures.
Construction	Evaluation of the quality of the applied materials and the built constructions during the building process as agreed on.
Translation	Evaluation procedures for whole building systems in principle should be described in the design phase.
Use	Evaluation of the quantitative performance criteria of the new building, that were derived in the design phase. They may be linked directly to the functional/qualitative performance requirements in the brief.
Translation	If the user requirements change, the building performance should be weighted to the new requirements.
Renovation – Demolition	The building performance should be checked on a regular base to identify whether the building meets the performance requirements set. Deviation may lead to a renovation plan or a new building (> Initiation-Brief).

To validate the developed framework principle (Figure 2), in relation to Table 1, the ISIAQ-CIB TG42 Guideline on Performance Criteria of Buildings for Health and Comfort [12][12][12] has been applied to fill the framework. The result of this is a database where the separate paragraphs of the report are organized towards the three axes of the framework and to the environmental attributes that are dealt with. A search on, e.g., a specific stakeholder or building phase results in the specific paragraphs that relate to those criteria. This example has been made accessible through the PeBBu Domain 2 homepage (http://www.bouw.tno.nl/pebbu).

The idea of the framework is that such a database is extended with similar information (reference or fully included) for all building phases, stakeholders and building objects, preventing overlapping and contradictory information. It should also include translation guidelines, amongst others evaluation procedures. In a further development the database may also function as a digital blueprint of the building (from initiation to demolition).

The example has shown that the principle of the framework functions. However, it is regarded crucial to apply a useful (not too large) division of the Stakeholders and Building Phases. For the

Building Object such a feasible subdivision was not established. It will require more effort to develop a general well applicable division that can be used for the framework. The search facilities as available through internet allow a quick scan of the available information.

4. Research agenda

Following the state-of-the-art the next step in the process of PeBBu is the development of a research agenda that lists developments that are regarded required to enhance the performance-based approach with respect to the indoor environment and in particular healthy building. The developed methodology and framework have been applied to set up this research agenda. Figure 3 summarizes the important topics.

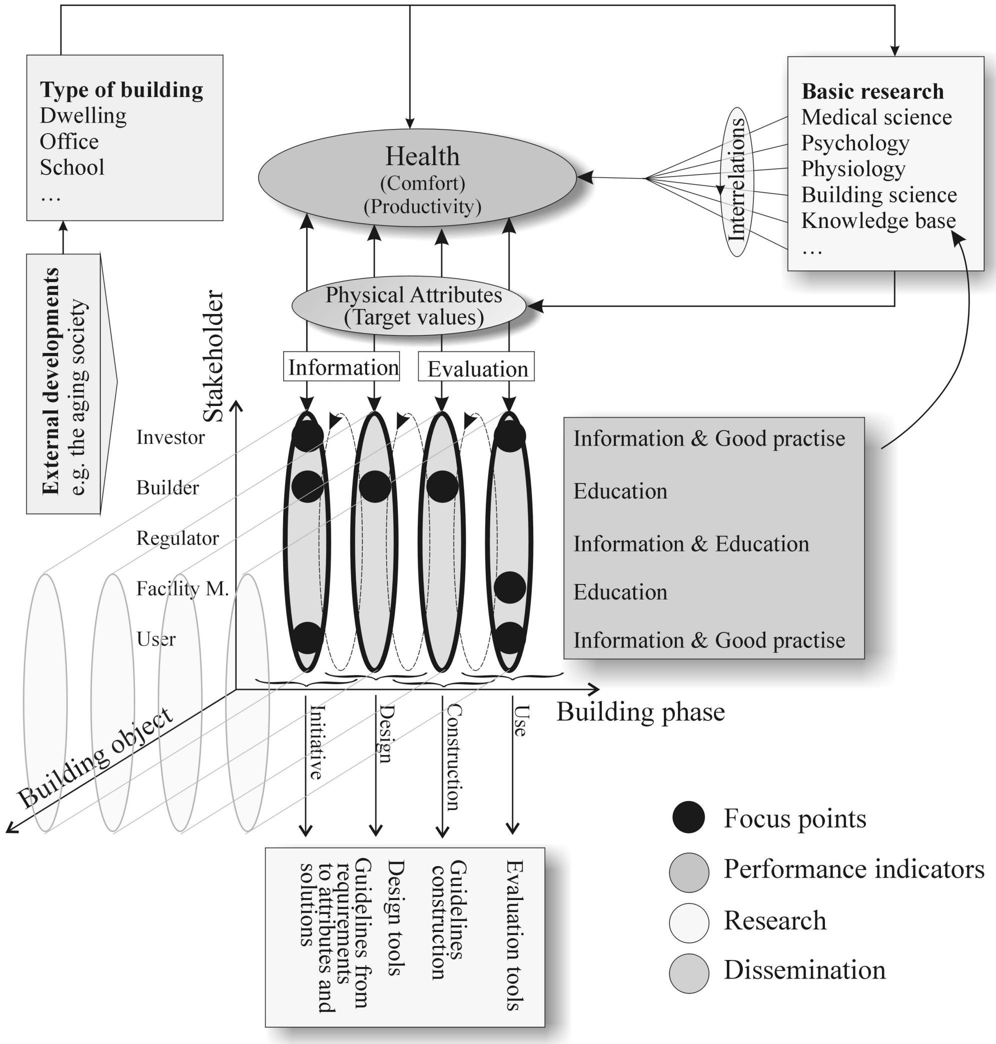

Figure 3: Research agenda for the PB approach in relation to the indoor environment.

Figure 3 has the developed framework as a base. On the axes the Stakeholder, Building phase and Building object are positioned. In the figure the focus is on the Stakeholder and Building phase. The literature study has indicated a lot of research on individual building objects and components, but it has proven to be difficult to subdivide the building in a sensible listing of building objects and components. Furthermore, developments described in the state-of-the-art at first instance are focused at whole building level or its major components. In the yellow box above the framework major research areas at basic level are shown to come to further definitions for performance indicators as health (and comfort and productivity) and to target values for (physical) attributes that relate to that. Developments are ongoing in this area, but it is noted that especially from a medical point of view a sound basis to a large part still is lacking (e.g., dose-response relations and causality). Psychology and physiology are topics that have had little attention thus far in relation to indoor environment and health. Furthermore, it is obvious that interrelations are present between psychology, physiology and exposure to the indoor environment with respect to the appreciation of that indoor environment. Building science and the knowledge base have formed the major part in developments relating to indoor environment and health. Based on the envisaged developments, the latter two will remain important research items in order to come to healthy buildings.

For the stakeholders and building phases the subdivision in overall terms is in included in the framework. The gray ellipses indicate that in every stage of the building phase all stakeholders in principle are present. However, focus points indicate the important stakeholders in each phase. The dotted (ellipse) arrows between these ellipses indicate the translation between the separate phases. The relation with the performance indicators is acknowledged in each phase, be it informative or through evaluation.

For the different building phases several research items can be identified. Most of these research items relate to the translation of information (higher level subjective to lower level objective and reverse) and to support tools for the evaluation (in the design, construction and user phase). Ongoing research at material and component level are not explicitly mentioned in the figure but can find their way via the framework.

Dissemination, an important aspect in the understanding and appreciation of the PBB approach, should take place at stakeholder level. The three most important topics for dissemination are Information, Education and Good Practise. The manner how this is presented to the respective stakeholders however will have to differ significantly. E.g., the communication to new users of a building to prevent misuse, or displaying the current health status of a building.

Finally, the gray boxes indicate that the research agenda should have the type of building as a reference and of course should adhere to developments that arise outside of the framework scope.

5. Conclusions

The results from the Thematic Network PeBBu indicate that PBB, in the Indoor Environment domain, already is being applied to some degree in the different phases of the building process. Furthermore, attention on this topic has increased significantly in recent years. However, mostly application is restricted to a single building phase or building object and little information is yet available on the translation of qualitative performance requirements to quantitative implications to the building. This hampers the further introduction of PBB in the building process.

The presented state-of-the-art includes more than a summary of existing information. The topic required more preparation as little consensus on the topic was available in literature. The PeBBu network presented a good platform to generate this consensus. Nevertheless, the topic remains complex and very extensive.

For performance requirements on health and comfort several interesting initiatives are ongoing or have recently been completed. The work in HOPE and ISIAQ-CIB TG42 are good and practical examples of that. However, a lot of work still is required before PBB can completely replace the current prescriptive building methods, if possible at all.

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The relationship between performance-based building and innovation: An evolutionary approach

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Abstract

There is growing consensus within research and industry communities that appropriate performance-based building approaches yield better performing buildings than prescriptive approaches. However, there are two schools of thought on the relationship between performance-based building approaches and innovation which are often in debilitating opposition. The 'content' school champions that performance-based building is the innovation in itself. In contrast, the 'contextual' school advocates that performance-based building provides the enabling environment to stimulate a raft of innovation activity which may include prescriptive, as well as performance-based, elements.

This paper argues that these two schools are not in conflict; indeed, there is significant value in recognizing and integrating them to form an evolutionary approach which promotes continuous development and use. A framework is offered which conceptualizes the performance-based approach as an evolutionary cycle of innovation across industry and project contexts, and between social and technical systems.

Key words: Performance-based building, innovation, evolutionary model

1. Introduction

Performance-based building (PBB) is intertwined with the present interest in, and momentum towards, performance-based building codes and standards (for example, see [6], [10], [12], [13], [17]). The key driver for this trend is the view that traditional prescriptive approaches act as a barrier to innovation. Within this context, discussion within the PeBBu Domain 8 community (http://www.pebbu.nl/maincomponents/scientificdomains/domain8/) has produced two schools of thought regarding the relationship between performance-based building and innovation. The 'content' school of thought has advocated that PBB is the innovation in itself, and that PBB approaches replace traditional prescriptive approaches with a new paradigm. In contrast, the 'context' school of thought has argued that performance-based building provides the enabling environment to stimulate a raft of innovation activity which may include prescriptive, as well as performance-based, elements. This paper argues that these two schools are not in conflict; indeed, there is significant value in recognizing and integrating them to form an evolutionary approach which promotes continuous development and use. A framework is offered which conceptualizes the performance-based approach as an evolutionary cycle of innovation across industry and project contexts, and between social and technical systems.

2. Key issues from the literature

2.1 The 'content' school: PBB as the innovation

The 'content' school advocates that PBB is *the* innovation which progresses "the practice of thinking and working in terms of ends"[14, page 4] through the creation of performance-based codes and regulations which are implemented at a project, technical system level. Averill [2, page 18], for example, emphasises the key challenge of PBB as the "quantification of the level of performance which a building material, assembly, system, component, design factor, or construction method must satisfy." The 'content' school posits PBB as a direct replacement for traditional prescriptive approaches which are viewed as acting as a barrier to innovation in that "improved and/or cheaper products may be developed, yet their use might not be allowed if construction is governed by prescriptive codes and regulations" [11, page 12].

The underpinning assumption is that this body of technical regulations and codes will stimulate a 'technical system push,' linear process of innovation, i.e. the development of PBB regulations and codes lead to a flow of new materials, components, systems and processes at a project level. Policy makers and researchers involved in the development of PBB regulations and standards commonly (if implicitly) draw upon this model to champion the need to move away from procedural, rule-centred regulation, which they view as being synonymous with prescriptive regulations which encourage minimum compliance, to a more flexible approach that allows relevant actors to move beyond compliance to sustainable innovation. Bowen and Thomas [5, page 3], for example, stress that PBB codes enable designers and contractors "the freedom to choose one of several possible means to achieve the required performance and therefore provide for flexibility and innovation."

Commentators, however, are cautioning against the unreflecting displacement of traditional, prescriptive approaches with PBB codes and regulations, and are emphasising the need for the *appropriate* use of PBB which fit the particular needs of the context in which it is being used (for example, [7], [16]). Baark [3, page 13] notes, for example, the high cost of managing risk intrinsic to novel solutions with the argument that, "considerable obstacles in pushing forward innovations related to construction projects arise from the existence and interpretation of [performance-based] building codes and regulations. When a new technology is proposed for a construction project, getting government approval turns out to be decisive …[and that] …many engineering consultants regard the efforts required to provide justifications for innovative solutions as excessive. The money and time involved in such endeavours can certainly be a discouraging factor for the engineers during their thinking process." This argument has been paired with the note that "prescriptive codes provide a simple 'cook-book' approach and, for the majority of construction projects … they provide the least costly method of ensuring an acceptable level of [performance]" [5, page 3]. The need for a more contingent approach to PBB which appreciates differing contexts and, thus, different requirements, has fuelled the claims of the 'context' school of thought detailed in the next section.

2.2 The 'context' school: PBB as an enabler of innovation

The 'context' school of thought view PBB as a guiding framework which provides a stimulating, supportive environment which encourages innovation, be it traditional, prescriptive or PBB codes and regulations, or a combination of the two, to provide buildings which "meet all the goals established by society and the client [2, page 18]. The 'context' school of thought is grounded on two key assumptions. First, it adopts a contingency premise that the PBB approach is not universally applicable to all projects in all circumstances. Rather, a contingent view of PBB is promoted which appreciates projects with different characteristics and circumstances require different mixes of PBB and / or prescriptive elements. This argument is captured in Figure 1 which suggests, on the left hand side of the diagram, that where the client system requirements are known from the start, a 'product' view of innovation is appropriate and that this is best supported by a prescriptive approach. Indicative scenarios of this position would be repeat projects with a sophisticated client and / or simple, standard performance requirements. In contrast, where there is a need for a co-evolution of requirements between the client system and the project team, as depicted on the right hand side of the diagram, a 'process' view of innovation is appropriate and best sustained through a PBB approach. Indicative scenarios would be a one-off project with an unsophisticated client and / or complex, novel performance requirements.

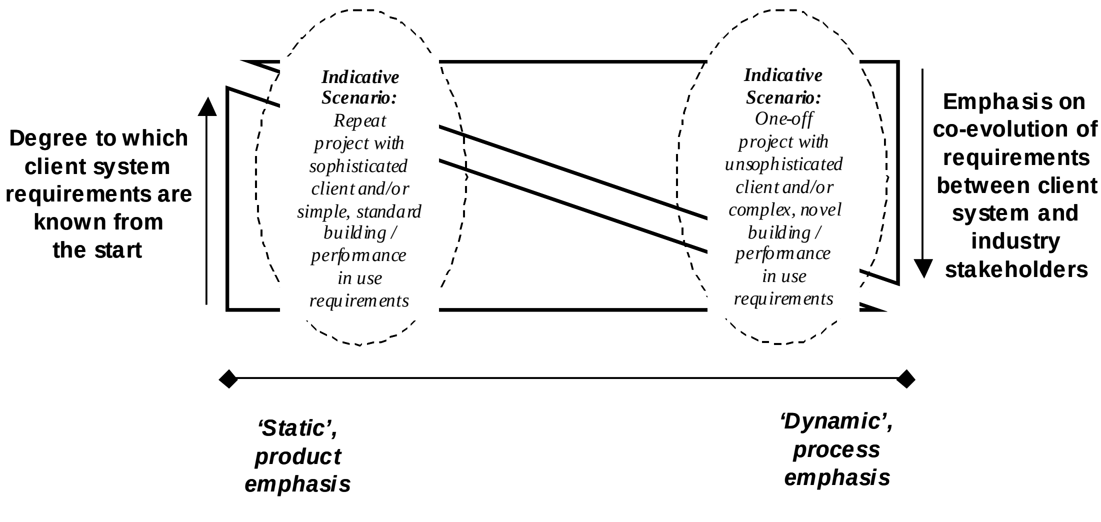

Figure 1: Product / process innovation continuum

Second, the 'context' school emphasises a social systems perspective which argues that innovation is determined by the nature and intensity of interactions, interconnectedness and synergies from a wide spectrum of agents which gravitate around a project setting. Inter-organisational networks promote and facilitate the development and exchange of knowledge and resources that are needed to encourage learning and innovation in participating companies (for example, see [4], [8], [15]). Indeed, it has been argued that the greater the number of inter-organisational networks a company is involved in, the greater the likelihood of generating and supporting successful innovation (for example, see [1]). PBB is seen as providing a discourse to shape beliefs and expectations of social system actors, and, in so doing, enable, facilitate and align activities of actors to forge a pluralist technical system made of performance-based and prescriptive elements. Adapting Edquist [9], the 'context' view of PBB has social system learning and innovation at its core through the accommodation of various ambiguities and the promotion of the diffusion of different, contingent, conceptualisations of PBB; and, as a consequence, provides a broad framework rather than formal theories of action.

3. A synthesis of the 'context' and 'content' perspectives of PBB: An evolutionary approach

The 'context' view offers the insight that PBB is a driver of innovation by providing a guiding framework which envisions and supports social interaction that stimulates context-specific configurations of prescriptive and / or performance-based elements. In apparent contrast, the 'content' perspective presents PBB as the innovation, in that it provides the technical tools and methodologies to implement performance-based approaches, and which replaces prescriptive approaches. These two views are, we argue, not contradictory, but complementary. An evolutionary model is advocated (see Figure 2) which dynamically links, consolidates and further develops the social system ('context' school) and technical system ('content' school) dimensions of PBB across industry and organisation / project contexts. The model operates as follows. First, it is accepted that PBB does not function independently, but that in order for it to be adopted and used, PBB must be part of a larger configuration of mutually attuned elements such as infrastructure, knowledge, skills, organisation, regulatory standards and cultural norms, through which the PBB approach can be handled productively by a range of actors. PBB, therefore, must be embedded within the industry context at a social system level to a degree where there is sufficient *confidence* in PBB as an approach to be considered as one of a portfolio of viable options which can be *adopted* by organisations in project contexts, and which the industry wide knowledge (in the form of 'good practice', codes and regulations) can be *developed* at a technical system level.

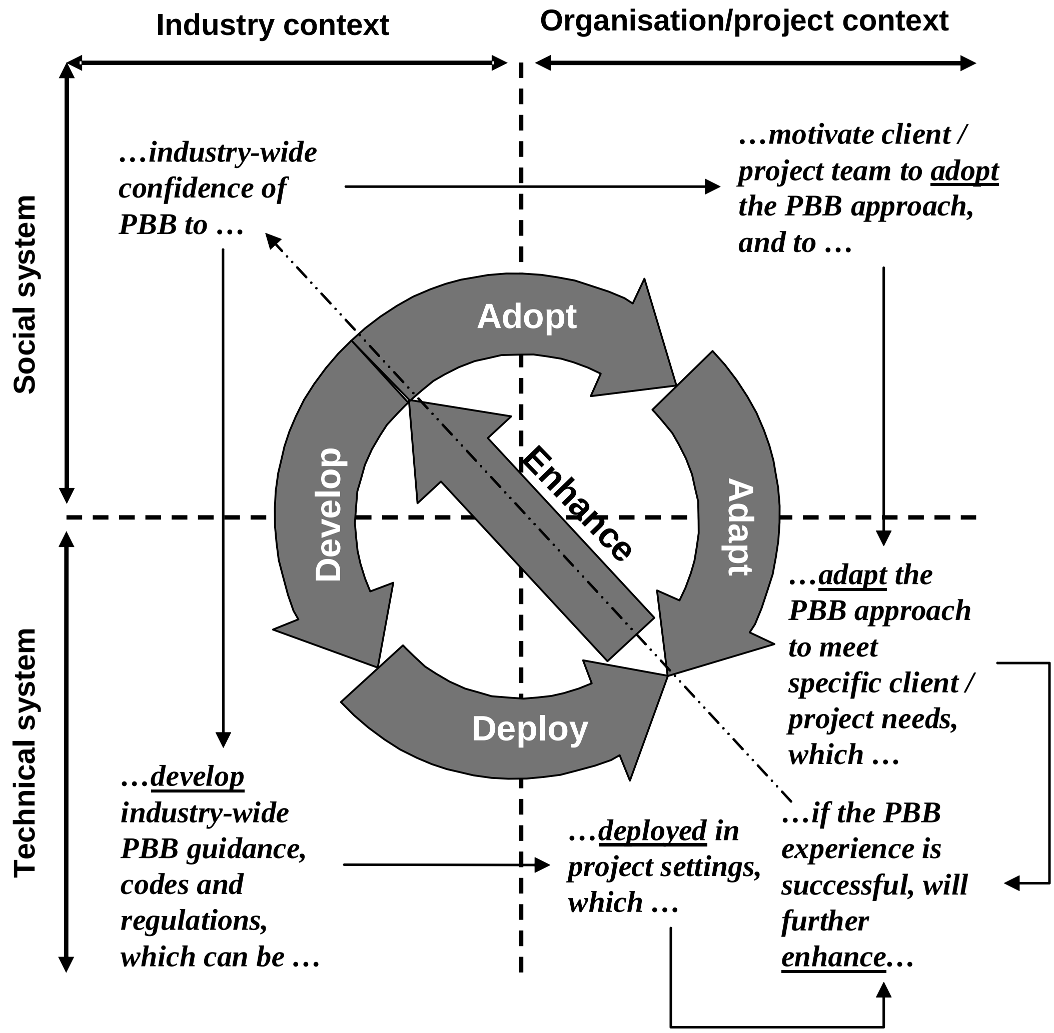

Figure 2: An evolutionary model of performance-based building

The network of organisations within a project context, having the confidence and *motivation* to adopt the PBB approach within a project context, then *adapt* it to meet the particular characteristics and needs of the project. The adoption and adaptation process is a sense making and negotiation process between the project participants at a social system level, before the resultant PBB approach is implemented at a technical system level. This process will involve the *deployment* of appropriate knowledge from the industry context, technical system repository. Finally, if the PBB experience is fruitful at a project level, the confidence and learning will feed back to the industry context social level to further *enhance* the motivation to consider PBB as a viable option in future projects, and to further development the industry context technical system. The cycle above is depicted as a positive one; however, the cycle might be negative, in that if the experience of PBB within a project setting is negative, the feedback to the industry system social context will undermine the motivation to further consolidate and develop PBB as a viable option.

4. Conclusions

The focus of this paper is to delineate two schools of thought on the relationship between performance-based building and innovation. The 'content' school which champions that performance-based building is the innovation in itself. In contrast, the 'contextual' school advocates that performance-based building provides the enabling environment to stimulate a raft of innovation activity which may include prescriptive, as well as performance-based elements.

This paper has argued that these two schools are not in conflict; and there is significant value in recognising and integrating them to form an evolutionary approach which promotes continuous development and use. A framework has been offered which conceptualises the performance-based approach as an evolutionary cycle of innovation across industry and project contexts, and between social and technical systems.

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Performance-based Design: bringing Vitruvius up to date

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Abstract

A performance-based design (PBD) is a building design that is based on a set of dedicated performance requirements and that can be evaluated on the basis of solution independent performance indicators. The performance-based design approach is a means to enhance the professionalism and the client orientation of the building design sector. It is aimed at satisfying the real client needs ('answering the question behind the question') and leaves the design process open for creative and innovative solutions. The performance-based approach makes 'integral design', with parallel, interrelated contributions from all design disciplines imperative. Although PBD has been put to practice in many countries to some extend, design practitioners appear to be hardly aware of it. Actions need to be undertaken to enhance the awareness of PBD. Performance based building regulations have proven to be a key success factor in the implementation of PBD and governmental clients should take the lead in further implementation.

Keywords: Performance-based design, client orientation, performance requirements, design process, design assessment

1. Performance-based Design

1.1 Backgrounds: scope and objectives

'Design of Buildings' is one of the scientific domains (Domain 3) of the Thematic Network Programme 'Performance-based Building' (PeBBu), that is funded by the European Union. Since the start of the PeBBu Programme in 2001 some 40 experts from 18 countries participated in the domain work.

The scope that has been chosen for PeBBu Domain 3 is strongly related to the notion that the 'end user' of built facilities becomes more and more important in the building process. A strong incentive for performance-based design derives from this 'emancipation of the end user'. 'The' end user demands quality from his own perspective. During the last few years it has become more and more clear that it is an economic necessity for the building industry to act more consumer oriented and to pay more attention to meeting with user requirements. As a result and in the field of performance-based building, a certain shift from a primary focus on performance specifications for building parts to a mix of this 'hard' perspective and a more 'soft', holistic perspective of performance-based building can be seen. In the latter perspective the focus is e.g. on the management of functional user requirements and user involvement during the design process and beyond. Which is basically a shift from solving an internal problem of the building industry to solving the end users' problem.

Performance-based Design (PBD) is considered to be of strategic importance for achieving the overall PeBBu objectives, especially because a building design determines to a large extend, intended or unintended, what the performance of the building in use will be. In this respect two aspects are of crucial importance in the design stage:

- making sure that the right users' performance requirements are considered;
- the prediction of the building performance on the basis of (preliminary) design results, in other words the assessment of the design.

This leads to the following issues that are addressed in the Domain's work:

- the translation of client and user needs into assessable performance specifications (or: the matching of user requirements and performance specifications of built assets);
- classifications and formats for performance requirements and specifications;
- the management of client and user involvement in the design process;
- assessment methods for design results.

The objective of the Domain 3 work is to clearly define these issues, give a comprehensive state-of-the-art overview and, from that, give recommendations for future research in these fields. A second objective is to develop modules for programmes that aim for the education and training of design professionals. These modules will be aimed primarily on enlarging the awareness of Performance-based design.

The essential role of Domain 3 within PeBBu is about the integration of knowledge and systems from other PeBBu domains in the context of real building designs. The building design is where it all comes together. More information can be found in the Third Domain 3 State of the Art report "Bringing Vitruvius up to date", that is published on the PeBBu website (www.pebbu.nl) [1].

1.2 Performance-based Design defined

Performance-based building is concerned with orientating activities around the performance in-use of built environment products and services and extending this approach as far back along the supply chain as is appropriate. PBB is about what a building should do for the client, the users and other stakeholders, rather than about how the building should be constructed. Thus, stakeholder requirements, together with legislative building regulations, are very important in the context of Performance Based Design. Performance requirements should express the real user needs behind the question for a built product. Following this principle a Performance-based design can be defined as follows:

– A Performance-based design is a building design that is based on a set of dedicated performance requirements and that can be evaluated on the basis of performance indicators.

However, Domain 3 'Design of Buildings' is not only about the result of a design process, but also and primarily with that process itself. A Performance-based design process can be defined as follows:

– A Performance-based design process is a process in which performance requirements are translated and integrated into a building design.

2. State of the art of Performance-based Design

2.1 PBD in general

The Domain 3 inventory of the state of the art shows that PDB is mainly an issue in research and education as yet. Design professionals (architects and engineers) are generally not very aware of PBD. In this respect a distinction should be made between two different approaches to PDB*:*

– designers and engineers have to meet with performance based client briefs and building regulations;

– designers define their work in a functional design plus a set of performance criteria, rather than work out the design traditionally in technical drawings and specifications.

The first approach can be recognised in most building projects in countries that apply performance based building regulations, mostly countries in the northern part of Europe. Applicants for building permits have to prove that the designs comply with the regulations, so every design professional is involved in PDB to some extend, consciously or unconsciously. Performance based building regulations and codes often include performance requirements for safety (structural safety, fire safety, earth quake resistance and so on), health, serviceability, energy efficiency and environmental impact.

The second approach is closely related to performance based procurement. Up to now, this approach has only been put to practice on a relatively small scale, mainly in the same northern countries. Mostly government building agencies take the lead; they organize pilot projects and/or experiments to set an example for innovation of the building process. The general idea is that the 'demand side' of the building process defines a functional design and a set or performance requirements, allowing the supply side to choose the most suitable technical solutions matching these requirements, availability and cost. This second approach to PBD has hardly been put into practice in non governmental projects as yet. One of the barriers is that clients, apart from a few very professional clients, do not trust this kind of procurement, that they experience as rather abstract and intangible and therefore too unsure and risky. They often prefer to be able to control the whole design and building process.

In general engineers and technical designers are more used to working with performance requirements than architects. The main design areas where performance based design and procurement is applied, are service engineering (acoustics, lighting conditions, indoor climate, air quality, and so on), energy consumption and maintenance.

2.2 Translation of client and user needs into assessable performance specifications

Interesting methods for the matching of client and user needs and performance specifications can be found in e.g. the Netherlands and Canada. The Dutch Government Building Agency (GBA) e.g. is developing a computer aided interview technique for (future) users of office buildings. Dependent on the combination of answers that are given to predefined questions ('question tree'), the computer generates a set of specialist performance requirements. The system is based on fifteen years of experience with the performance based briefing and procurement.

In Canada the International Centre for Facilities (ICF) developed the 'ST&M-approach' ('Serviceability Tools & Methods') [2]. The method comprises a set of standard tools for measuring in broad terms what is needed and what is provided; it compares what functionality the occupant groups require and how well assets support those needs. Scales are used, giving a range of standard levels, so that stakeholders can choose how much of each topic is needed. For every topic there are two scales. The first is a functionality requirement scale giving levels of functionality from 0 to 9 (demand). The second is a serviceability scale for assets, also ranging from 0 to 9 (supply). Each couple of scales is calibrated. There are scales for some 200 topics. This is probably the most elaborated and easy to use example of how performances specifications can be matched with user requirements (and the other way around).

In many countries client briefs are usually solution oriented. They often contain technical and space solutions, that belong to the domain of the building industry. These are hard for clients and end users to understand, because they are not involved in that domain. Research by VTT in Finland shows that performance based briefs turn out to be easier for the end users to understand, because they appeal more to the end users' own domains and processes. Moreover, performance based requirements in briefs give designers possibilities to fully exploit their knowledge accomplishing creative and flexible solutions.

2.3 Classifications and formats for performance specifications

A survey of material from only a few countries already shows a wide variety of 'classifications' that are used for arranging performance specifications in briefing methods. Even on a national level several different classification methods are encountered. There is a clear need for a generic conceptual framework for performance based design and building and a common set of basic definitions.

2.4 The management of client and user involvement throughout the design process

As this is quite a new topic, there is little information available about the state of the art in this field. The best examples probably come from project developers who open project websites, allowing future users to follow the process online. Several developers offer future users the opportunity to give input and choose from options in the course of the process. These project developers experience that, when they offer these opportunities, the processes have to be very transparent; it has to be very clear for all parties involved until which moments which decisions may be postponed, in order to prevent frustration of the process and extra costs. Several market parties in Western European countries struggle with this. In general we may conclude that the building industry is not a very user oriented industry.

In several countries we see large scale programmes aimed at structural changes in the building industry. Examples are ‘Rethinking Construction’ in the UK and the ‘Process and Systems Innovation Programme for the Building Industry’ (PSIB) in the Netherlands. One of the common goals is to change construction into a more consumer oriented industry. Further development of the performance concept may contribute to that, as this concept is user oriented by nature.

2.5 Assessing design results

Too often the requirements are not met in the final product. There are various reasons for this: cutting costs in some phase of the project, inability to find suitable design solutions to fulfil the requirements, forgetting the original requirements, and so on. To avoid this, an early and continuous verification has to take place in the design process (Ang et. al, 2001 [3], Becker 1999). The user has to be sure that the desired performance targets will be fulfilled. And if this is not possible, the user has to know this on beforehand.

Assessment methods may vary from simple measuring (e.g. the amount of net square meters offered) via standardized calculating (e.g. the strength and stability of building structures or the energy loss) to simulating certain aspects of the behaviour of the building in-use (e.g. daylight penetration in different seasons and under different weather conditions). In some EU member states national building regulations are more and more performance-based. Also European regulations, that have to be implemented in the national building regulations of all EU member states, are as a rule performance-based. Very well known of course is the Construction Products Directive (CPD). Performance-based regulations often refer to national standards, where not only performance levels for building parts and properties, but also the corresponding assessment methods are defined.

Assessment methods in European and national standards are mostly aimed at the testing of actual buildings or building products. However, one of the main problems in PBD is how to predict the performance of a building on the basis of a design. For many quality aspects the 'total building performance' depends on a complex interaction of many influences. On the one hand there are no validated, standardized assessment methods available to predict the total building performance, but on the other hand this performance will determine the client's perception of the quality delivered to a great extend. The only way to do it is by simulation of the building behaviour, using integrated data models. All over the world institutes and universities are in the process of developing simulation applications to facilitate this, using modern information and communication technology (ICT).

2.6 Barriers

According to the members of Domain 3 the main barriers for further development and implementation of PBD are the traditional culture of the building process, the suspicion of design and engineering professionals that PBD will further undermine the design profession and the conviction of design professionals that the responsibility for the technical design cannot be separated from the responsibility for the functional and architectural design (which is the case in performance based procurement). Also many architects believe that the most important quality aspects of buildings cannot possibly be translated into performance specifications.

Other drawbacks that have been mentioned are the segregation and fragmentation of design, engineering and construction, the uncertainty about risk and liability, the (lack of) professionalism of clients, lack of experience. Moreover, during the economical boost of the last ten years, there was little incentive to change. Maybe today, while the whole European building industry suffers from an economic crisis, there is more readiness for innovation.

3. Ten reasons for Performance-based Design

PBD is not a goal in itself, it is a means to reach the 'higher' goal of creating more added value for the client, the end user and other stakeholders. The performance-based approach requires a different attitude, a different way of thinking about designing buildings than in the traditional design process. Implementing the performance-based approach in the design process requires a change of culture. Experience teaches that cultural changes do not occur overnight; it takes a lot of effort and a lot of time. Design professionals will have to be convinced. Many of them seem to consider PDB as a (further) degradation of their positions and interests in the building process. The Domain 3 members thought of ten reasons that make it worthwhile for design professionals to put effort into the performance-based approach.

1 PBD provides for a more client oriented way of thinking and working in the design process. The performance-based approach is basically a client orientated way of thinking and working, especially in the design process.

2 Performance-based thinking helps clients and designers to gain better knowledge about how a building operates or should operate. As performance-based building primarily has to do with what a building should do for the owners and users, it enhances the awareness of how a building-in-use operates or should operate.

3 PBD leads to cost effectiveness, better quality and better client and user satisfaction. Quality, in client oriented way of working, can be defined as the extend to which a product or service meets with the client's and end users' needs, wishes and expectations. Performance requirements intend to express clients' and users' needs explicitly. A performance-based approach in design offers better conditions for meeting with those needs and – as a result - for better quality and better client and user satisfaction.

4 European and national building regulations are more and more performance-based (as opposed to prescriptive codes). Designers will have to prove that their design solutions meet with the legislative requirements. Therefore it is imperative that design professionals adopt the performance-based way of thinking and working.

5 PBD prevents designers from tumbling into solutions from the very beginning without proper understanding of the real client and user needs. In practice designers often start to develop solutions immediately. Also owner and user requirements in briefs often seem to be recipes for solutions, rather than descriptions of the performance of the building in-use. This may obscure the real needs behind the owner and user requirements. Moreover it may rule out unexpected creative, innovative and/or cost effective solutions on beforehand. PBD stimulates thinking about 'the question behind the question' before jumping to conclusions.

6 PBD provides architects with the tools to be the integrator in the design process. Vitruvius already stated ten centuries ago, that architecture is the fusion of functionality, solidity and beauty. With this definition, Vitruvius made a strong plea for integral design. PBD is also all about integral design. Someone has to do the integration of contributions of all parties involved and the architect is best positioned for that. In many countries the architect lost his integrating role in the building process, because he was not able to cope with all the technical systems. The PBD concept provides him with the tools to be the integrator again. It's like bringing Vitruvius up to date in a modern setting.

7 PBD offers better conditions for creativity and for generating added value. As performance-based building codes and requirements allow designers to come up with a variety of solutions, the performance-based approach will enhance creativity and innovation in the design and building process, with more added value for clients and end users as a result.

8 PBD offers the opportunity to make better use of knowledge and expertise of contractors and suppliers, allowing them to come up with innovative, cost effective solutions. Multitudes of building concepts, techniques and products are available for the building industry and more are added every day. It is impossible for designers to have knowledge of all available concepts, techniques, products and new developments. Contractors (and suppliers) often have better knowledge of the market, but also they cannot possibly have mastery of all available concepts and techniques. They have to specialize. But when they are confronted with building designs that are specified in detail, they will often not be able to use their own specializations. When architects and other designers refrain from giving detailed prescriptive specifications

for every building part and complete the functional and aesthetic design with a set of performance specifications for building parts instead, allowing contractors to use their own techniques and market knowledge, that might lead to cost effective solutions, better quality and more value for money for the owners and users.

9 PBD helps to fill in the building industry's responsibility for the environment. Future generations have the right to live in a healthy and sound environment. Legislation in this field is mainly performance-based, leaving the responsibility for how to meet with the legal requirements to the designers to a great extend.

10 PBD is common practice to some extend already. In practice most designers already are involved in PBD to some extend, consciously or unconsciously, e.g. in relation to meeting with energy consumption and other environmental requirements. So to most designers PBD is not a completely new concept. Besides that it's important to understand that total systems of performance-based building or design do not exist. PBD can be applied in a more or less extensive form, depending on the circumstances of a project. This means that designers do not need to change their 'normal' way of working from one day to another in order to implement PBD.

4. Performance approach in the design process

The performance of a building or a building part is always the result of the interaction between different solutions for different subsystems, like the architectural system, the structural system, the climate system and so on. This is depicted in diagram 1.

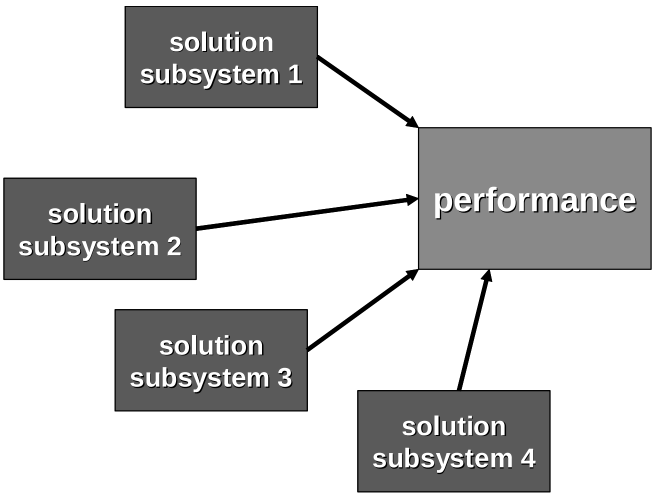

Figure 1: 'Performance' as the result of different solutions for different subsystems.

Designers have to deal with systematic interrelations between different performance specifications, which often relate to different fields of expertise. Thus, the performance-based approach calls for integral design, with parallel, interrelated contributions from all design disciplines involved. The end user is probably not really interested in the performances of different subsystems; he experiences the performance of a built facility as a whole. The design disciplines will have to co-operate closely to create an integrated facility design. In some aspects also the expertise of the contractor and specialized subcontractors is needed to get optimal performance.

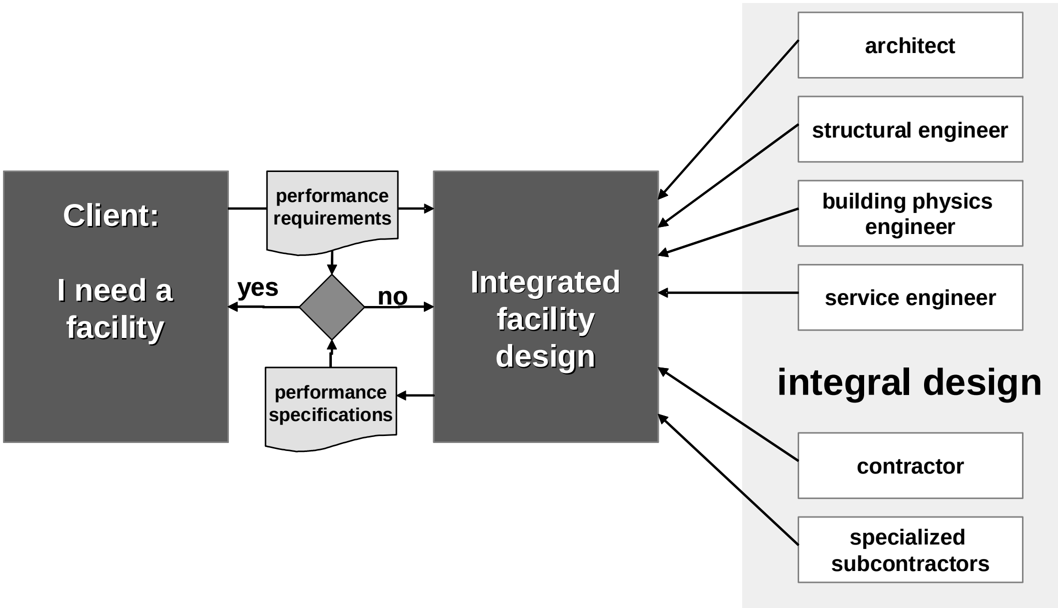

Figure 2: Performance-based Design calls for an integral design approach

As the Performance-based approach is the practice of thinking and working in terms of ends rather than means, it provides for openness to the infill of the design process. It provides suppliers (both designers and contractors) with the opportunity to come up with creative solutions. Therefore, in principle as many requirements as possible should be performance-based and measurable. Requirements and solutions (prescriptive specifications) should be mixed up as little as possible, as solutions will essentially always be compromises.

However, some essential aspects of design, such as architectural and cultural value, cannot be expressed in ‘hard’ measurable performance requirements. Nevertheless these aspects may be quite an important component in a stakeholder’s general appreciation of a built asset. This means that also in a performance-based design process, these aspects should be fully taken into account. Also a client should be free to choose a specific solution or product, if he really wants that. In other words: in practice it will be unwise to be too fundamental in following a performance-based design approach; a design process will always be hybrid to some extend.

It appears to be a world wide trend that clients and future users demand more involvement and influence in the building process as a whole and in the design process in particular. E.g. modern ICT provides them with the tools, like internet and virtual reality, that enable them to participate actively in the process. Moreover, it becomes more and more clear that it is an illusion to think that the design process can start with a complete and unchangeable client's brief. Also for the clients and users the design process is a voyage of discovery and they expect the designers to facilitate that voyage. The question is how to do that and at the same time improve the efficiency and manageability of the design process.

Already in 1992 the Dutch Building Research Institute (SBR) issued a report about a new system of briefing that allows clients to develop the brief in interaction with the design [4]. This should be done in a controlled process, in which briefing and designing are, though parallel, separate processes. According to this system, after each formally concluded design stage the brief should be updated and further completed with the information that is necessary for decision making in the next design stage. This process is depicted in figure 3 (‘ass.’ means assessment).

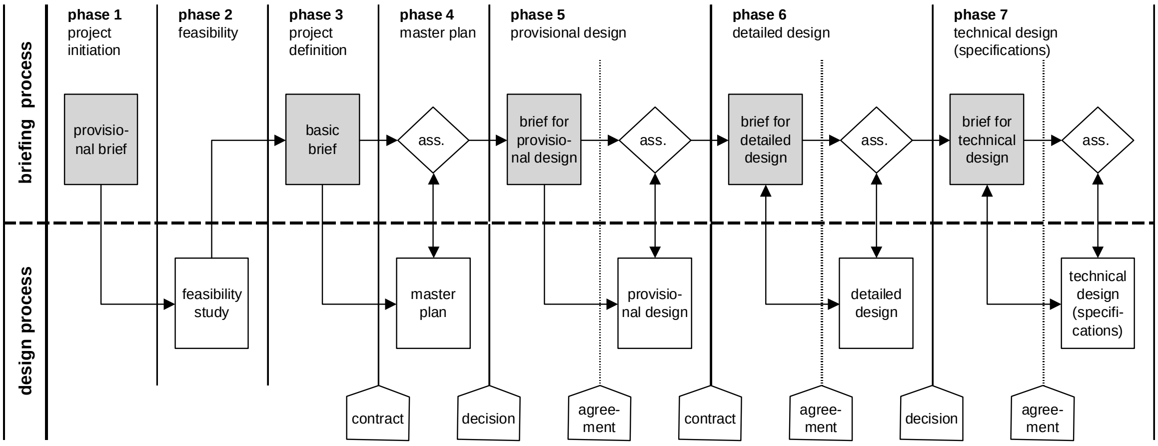

Figure 3: overlapping of the briefing process and the design process (source: SBR publication nr. 258, Rotterdam, 1992)

The principle is taken over by the Royal Institute of Dutch Architects (BNA) and the Dutch Association of consulting Engineers (ONRI), who recently issued a common ‘Standard Task Description’ (STD) for designing buildings in 2004 [1]. This STD [5] is basically a breakdown of the design process into interrelated tasks per phase for all disciplines involved (commissioning, architecture, building physics, interior design, structural engineering, service engineering, landscape design, project management). In this system, that will be the basis in the Netherlands for contracts between clients on the one side and architects and consulting engineers on the other, each new design phase starts with an evaluation, update and further elaboration of the brief. The STD has also been developed to facilitate integral design. Members of BNA and ONRI sensed that there is a growing demand for this among their clients.

5. Conclusions

Design practitioners are hardly aware of Performance-based Design (PBD) as yet, although many of them are involved in PBD to some extend already. The performance-based design

[1] Similar developments can be found in e.g. Norway, Sweden, Germany and New Zealand

approach has already been applied in different cases and countries, but not necessarily under that name. PBD is a means to enhance the professionalism and the client orientation of the building design sector. The time seems ripe for it, as there is a growing demand for integral design. In some countries tools for integral design are developed by associations of architects and consulting engineers. PBD calls for integral design.

It seems appropriate that actions should be started to enlarge the awareness of Performance-based design. In this respect the participant in PeBBu Domain 3 came up with the following suggestions:

- make existing projects or designs, in which the performance-based approach has already been implemented to some extend, more explicit (‘best practices’);
- government leadership in the implementation of PBD can be a powerful stimulus;
- incorporate the performance approach in design education;
- enhancement of “total building performance” in a life cycle environment (long term performance);
- performance based building regulations have proven to be a key success factor in the implementation of a performance-based way of thinking in building design;
- mutual recognition of performance assessment methods through standardization.

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Facilitating Innovation & Enhancing Trade – The Performance-Based Building Networks in Australia & Asia

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Abstract

This paper presents background development, an overview of programs, activities and accomplishments to date, and possible opportunities/challenges for further development of the Performance Based Building (PeBBu) Networks in Australia and East Asia. The primary goal in these efforts/activities is to effectively engage the key stakeholders that can help hasten and broaden the adoption of the performance concept in practice.

Keywords: Performance approach, performance based building, innovation, trade, stakeholder engagement

1. Performance Based Building

Performance Based Building is an approach to building-related processes, products and services that is concerned predominantly with the required outcomes (the 'end') and not with how these outcomes are achieved (the 'means'). This is in contrast to the traditional prescriptive approach, which tends to focus on specifying the method or solution for achieving the required outcomes.

Process requirements would include time, cost, profits, health and safety, and other process outcome indicators. The attribute requirements for product – which can be the whole building or any of its individual components – would include safety, health and amenity, maintainability, sustainability, etc. Service requirements involve requirements to support the users or businesses of the built facility during the occupancy stage (i.e. includes all facility management functions).

Performance based building:

- encourages better understanding and communication of client/user requirements, thereby reducing opportunities for disputes and producing delighted customers;

- allows the building practitioner considerable flexibility with regard to design solutions – encouraging innovation and providing the opportunity for cost-optimised solutions;
- facilitates international trade.

2. The PeBBu Networks

In order to progress the technical developments in, and the practical implementation of, performance based building, the CIB Board and Program Committee initiated the Proactive Program on Performance Based Building in the 1998-2001 triennium (Foliente 2000). Then with funding from the European Union (EU) Fifth Framework Programme, this was followed by the establishment of the Performance Based Building (PeBBu) Thematic Network, running from October 2001 to September 2005 (see www.pebbu.nl).

In 2003, the Australian Performance Based Building (Aus-PeBBu) Network was established to promote the performance approach in Australia (see www.auspebbu.org) and to facilitate linkages and exchange of information with the EU-PeBBu Network.

In 2005, an informal network of agencies or organisations in countries in the Asia-Pacific region formed Asia-Pacific PeBBu.

3. Aus-PeBBu

The network of Australian researchers and industry representatives who constitute Aus-PeBBu are not only participating in the meetings and activities of the European Union-funded (EU) PeBBu network, but also running activities (working groups, industry seminar/workshops and a project web-site) aimed at promoting performance based building in Australia.

The main developmental activity in the Aus-PeBBu network is incorporated into seven technical domains or working groups:

1. Building Materials and Components
2. Indoor Environment
3. Building Design and Engineering
4. Sustainable Built Environment
5. Innovation

6. Legal and Procurement Matters
7. Building Regulations and Standards

With one exception, these scientific domains match those in EU-PeBBu, to provide one-to-one correspondence of efforts and to maximise opportunity for participants in both networks to discuss similar topics and issues and to cooperate on matters of mutual interest.

The main difference in the program is the inclusion in Aus-PeBBu of a domain “Sustainable Built Environment”. With significant national and international interest, initiatives and investments in sustainable development, this is a timely topic.

With less funding and much smaller scope than the EU programme, Aus-PeBBu has a relatively stronger focus on facilitating the proactive application of the performance approach through best practice project delivery processes, instead of building regulation. The Building Code of Australia (BCA) had adopted the performance concept in the mid-1990’s (see www.abcb.gov.au). Australia’s experience in performance-based code development and implementation is very extensive, and shared with the members of the Inter-jurisdictional Regulatory Collaboration Committee (IRCC); IRCC is an unaffiliated committee of ten of the leading building regulatory agencies from eight countries (see www.ircc.gov.au/).

4. Asia-Pacific Network

Aus-PeBBu has now extended its informal network to East Asia, with counterparts in Japan, Singapore, Hong Kong, China, Thailand, Vietnam, Philippines and Indonesia at this time. The participation of the developing countries in the region is partially funded by the Australian Government under its Asia Pacific Economic Cooperation (APEC) Support Program.

The informal Asia Pacific network has as its primary goal the sharing of information, experience, expertise and efforts to promote the practical and effective implementation of the performance approach in building and construction in the Asia-Pacific region and in individual participating countries. Like Aus-PeBBu, there is strong focus on stakeholder engagement. Unlike Aus-PeBBu, we anticipate a greater focus on applications of the performance concept on building code and regulations and in product assessment, appraisal and evaluation (e.g. for trade purposes).

5. Common Issues & Objectives

The main factors that hinder widespread adoption and implementation of the performance concept can be grouped into technical and non-technical issues. Some of the lessons learned in running the

EU-PeBBu and the Aus-PeBBu Networks have been discussed by Bakens et al. (2005). An innovative technology diffusion strategy based on the “tipping point” principle, as applied in the construction industry by Foliente and Boxhall (2002).

Technical challenges have been identified by Becker (1999) and Foliente (2000). In this regard, the two Networks aim to contribute to the following areas of long-term technical development:

- Establishment of a whole-of-life performance framework (including performance indicators and criteria);
- Development of a guide on methods of establishing/setting performance;
- Expansion and maintenance of the database compendium of performance tools or methods that can be used to achieve targets (e.g. during design), and to assess/verify/evaluate performance in-service; and
- Establishment or development of a best-practice compendium of benefits of the performance approach based on actual/real projects (collected from each country).

In the Asia-Pacific Network, this will be facilitated by network members coming together for a series of annual seminar/workshops in different member countries over an initial 4-year period. It is anticipated that the network will be self-sustaining after this time.

6. Conclusion

From the CIB international membership and Europe, the performance based building networks continue to expand – first in Australia and now in Asia-Pacific. Mechanisms for a 2-way information flow from one network to another are implicitly in place. If managed properly – e.g. critical information and lessons from one network are passed on to another, people from one network get involved in another, etc – there is a potential for: (a) wider adoption of the performance concept in building regulations, procurement, delivery and management, and (b) greater opportunities for innovation and enhanced trade.

PeBBu has now extended its informal network to East Asia, with counterparts in Japan, Singapore, Hong Kong, China, Thailand, Vietnam, Philippines and Indonesia at this time. The participation of the developing countries in the region is partially funded by the Australian Government under its Asia Pacific Economic Cooperation (APEC) Support Program.

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Section II

Performance Based Building Framework and Tools

A comparison of international classifications for performance requirements and building performance categories used in evaluation methods

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Abstract

User requirements, building performance, performance indicators and building performance evaluation (BPE) methods are being discussed, developed and applied in various countries. There seems to be little consensus however, as to which building performance evaluation criteria and methodologies might best apply in which situations. By a comparative analysis of the methodological similarities and differences between the aspects and topics addressed in the "ASTM Standards on Whole Building Functionality and Serviceability", the NOPA (New Office Promotion association of Japan) Minimum Standard in Japan, the BPE tools and methods applied in Europe, this paper illustrates the various approaches to user requirements and building performance evaluation, as well as how user requirements are defined, which performance criteria are described, which indicators of capability are included, which measurement tools are used, and how the requirements of the stakeholders and the performance of the facility are compared. The paper concludes with a comment that in a global market, there is a growing need to build on these different approaches to create a more comprehensive standardized and universal methodology to state requirements, describe and choose performance indicators, and compare the two in order to verify that the building product or service performs as required.

Keywords: assessment; building information model: evaluation criteria; functionality; performance approach; performance indicators; quality; serviceability; suitability; sustainability; tools; user requirements

1. Initial positions and objective

The main drivers that are leading to the development of a Performance approach in building have already been often described. Knowledge of the current discussions about the performance concept as applied to building (PBB) will be assumed here ([1],[2],[3],[4]). How the

Performance approach applies both to the regulatory and non-regulatory context has been discussed through the contributions of both individual scientists and work groups (including CIB TG 11[1], W060[2] and PeBBu[3]) ([5],[6],[7],[8],[9]). There is agreement meanwhile that the use of a Performance-based approach in the building industry encourages innovations, allows for more open competition, promotes transparent procurement, and supports cost-effective building. As a result, several countries (e.g. Australia, Canada, Great Britain, New Zealand, Spain, The Netherlands, etc.) have decided to integrate Performance-based regulations in their building codes and to modify codes towards a Performance or Objective-based approach.

The Performance approach has originally been primarily concerned with improving the project delivery process for new construction. Early on, the focus was on how requirements of both occupying and non-occupying users in respect to “technical, physiological, psychological and sociological aspects”, as Gibson [10] puts it, could be achieved as might be “discussed and agreed between a client and a design team” based on a functional brief (program). Furthermore, until the early 1980s, performance standards considered primarily parts of buildings, building products, materials and components [10]. As such, until then, only marginal attention within the performance approach was given to requirements beyond the functionality during use of the physical elements of a building, suggesting that the performance approach was focused and applied *in a narrow sense* with an emphasis on the technical functions of the parts rather than the whole. In 1982, ASTM set up a different kind of sub-committee focused on the performance of whole buildings and facilities[4]. By 1995, ASTM approved the first set of standards that addressed the functionality and serviceability of whole buildings from the end user perspective.[11][12] This set of standards is based on a method and tools created by a team led by contributing authors Davis and Szigeti. Davis and Szigeti developed a method [13] for describing the functionality requirements of the users (demand), evaluating the serviceability of whole buildings and facilities (supply), and comparing the two using calibrated scales[5]. These scales include a combination of functional elements on the demand side, and a combination of physical features on the supply side. This method is currently being standardized internationally (ISO TC 59/SC14/WG10) and adapted to the needs of other countries such as France [14].

In continuing and increasingly intense scientific discussions, in part in the context of the EU funded PeBBu project [5], the Inter-jurisdictional Regulatory Collaboration Committee (IRCC), the International Council for Research and Innovation in Building and Construction (CIB) W60 and TG37, and the International Building Performance Evaluation (IBPE) Network [15], it is possible to identify a trend that is moving toward a clearly broader way of looking at building performance over the “Whole Facility Management Cycle” [10]. Other terms heard in discussions such as *total building performance, whole life performance, overall performance* or *integrated building performance* demonstrate that an expansion of the contents of the application area is currently taking place, similarly to an understanding that the project delivery phase is only a small part of the whole life cycle of a facility. These types of developments indicate that the concept of building performance is being applied more broadly which is defined by the authors as the *performance approach in a broader sense*. In addition to many other scientists and work groups, Luetzkendorf and Speer have also been concerned with the broader application of a performance approach. They build on the work of Davis and Szigeti

[13] and Balck [16] and suggest that a performance approach needs to also be used by the supplier / contractor to signal product quality, to consider the perspective and specific realm of interest of other actors (in addition to the end user), as well as in subdividing the contents of overall performance into individual aspects with relative independence [3].

The Performance approach in a broader sense is receiving increased attention. There are on-going discussions – including those involving international standardization – on how the description and evaluation of buildings should take place and how these can be harmonized (such as “Service Life Planning” (ISO TC 59/SC 14) and ”Sustainable Construction” (ISO TC 59/SC 17)). For instance, the approach is also being used as the basis for developing a system to evaluate the contribution of single buildings towards sustainable development. Functional, design, technical, economic, environmental and social aspects need to be considered simultaneously. A number of “multicriteria” decision support tools are currently being proposed, including a sustainability index for the measurement of sustainable performance. [40] The relative weight of different aspects to be considered will depend on the requirements of the client and other stakeholders for each project and the importance of the facility in support of the mission, goals, and purpose of the organization, or in support of the objectives of an individual or family. In addition, the use of a performance approach in determining the average useful life of buildings and building components is being discussed [17]. However, the methodologies developed, or considered by various authors and research groups, vary greatly. This paper discusses the general criteria and system which can be used to structure building performance in such a way that performance requirements, criteria and results can be more easily aggregated and dis-aggregated. In addition, the various ways of viewing the concept and developments surrounding the performance approach in North America, Europe and Japan are presented, examined and compared based on selected examples.

2. Suggestion for major performance categories

Expanding the performance approach with regards to its task, its interpretation and its area of application by including additional actors, concerns and supplementary functions requires developing major categories where user requirements are grouped in a coherent fashion.

2.1 Performance Categories

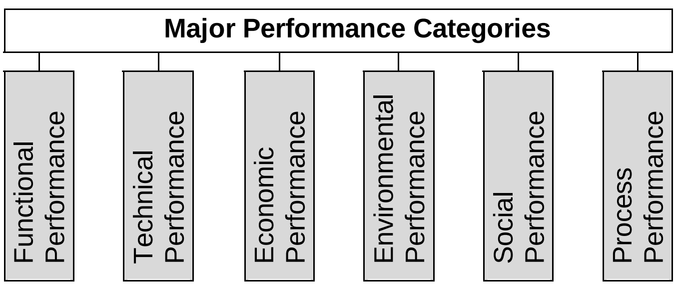

Figure 1: Performance categories

Figure 1 contains the authors' suggested performance categories and Table 1 details the categories by way of short descriptions and examples.

Table 1: Description of performance categories

Functional Performance Functional performance of a building describes and assesses how well use-specific activities and processes can be performed in the building. Criteria include suitability of the surface and space program for planned use, accessibility and barrier-free design, adaptability to changing user requirements and uses, etc. Functional performance is closely related to the needs of the building users and others such as visitors, and the public community.
Technical Performance Technical performance describes structural, physical and other technical features and characteristics. Criteria included suitability for the planned service life, load capacity, maintenance and revitalization capability, structural resistance to fire, control of noise transmission, heat insulation of building shell, etc.
Economic Performance **a) Real Estate Performance** Real estate performance is the earnings trend and value of a real estate property. It is especially useful for the decision-making processes of investors and property owners. A performance requirement is likely to be increased revenue and value. **b) Cost Performance** Cost and financial performance describes financial expenditures involved in planning, construction, operation, maintenance, demolition or waste disposal at a particular time or within the life cycle of a facility. The current criteria have moved towards LCC (Life Cycle Costing) methods. Cost performance is used by managers, planers, building users and facility managers to monitor and control costs. Investors and property owners especially consider non-allocatable costs.
Environmental Performance Environmental performance describes and assesses the building's features and characteristics relevant to its impact on the environment. The effects on both the local and global environment are considered. Energy and material flows and resulting effects on the environment are recorded. The use and conversion of areas are also considered in part. Low resource utilization and/or reducing effects on the environment contribute to improving environmental performance.
Social Performance The description and assessment of social performance is based on criteria that indicate the health, comfort and safety of users, visitors, residents and neighbors of the building. In addition, the building's cultural value is also usually assessed. Codes, regulations and standards provide a base for these performance requirements, but clients often choose to demand more.
Process Performance in Strategic Planning, Design, Construction, Operation, Maintenance, Management and Use The overall building performance is influenced by the quality of processes involving planning, construction, use and facility management. It is thus suggested that quality of planning, construction on site, management and building related services be described and assessed separately as process performance.

Taken together, the major performance aspects divided into individual categories form an information pool within which individual criteria (i.e. essential features relevant for assessment and decision-making) can be classified. The criteria in turn can be matched and measured with individual performance indicators. Classifying criteria within the system of categories depends on interpretation. Criteria can be meaningfully allocated to more than one category. For instance, the criterium 'health & comfort' can be allocated to both functional performance and social and compliance performance. In the authors' view, it is important that essential criteria are listed as fully and completely as possible. Performance results for individual criteria within each category can be obtained by means of testing, calculations or factoring based on scientifical methods. The performance requirements or results for criteria within one category can be combined into a single index representing the partially aggregated performance of the building. Similarly, the overall performance is deduced by full aggregation of the categories when required by the user or organization, on the basis of some calculation or algorythm. If weighting among individual categories is included, it should always be transparent and explicit. For instance, one category of requirements may be more important to the organization with regard to its mission(s) [18].

2.2 Interests and information requirements of stakeholder groups

The parties involved in the entire building process each have a specific scope of interests with various resulting information requirements. Each of the actors involved view and assess performance differently. For instance, the investor is primarily interested in the economic performance, particularly the property's earnings trend. The user and facility manager have a distinct interest in operating cost performance. Authorities and regulators are interested in environmental performance because of an interest in protecting the environment, and also in health, safety, security, fire, blast and seismic performance, and compliance with current codes and regulations. The actors seen as relevant are listed in Table 2. The number of actors involved, however, is larger. As a result, the interrelationships among all actors are more complex. The list represents merely a selection of the actors involved. Bakens *et. al.* [5] provides a more detailed look. Classifying actors to a supply or demand side is not fruitful because many actors can be on either side of the demand-supply dialog. A demand actor for a particular performance can also be a third party supplier further along the value-added chain.

2.3 Life cycle phases and events within the life cycle

A performance approach can be used in every phase of a building's life cycle. The authors refer here to the 6 phases set forth by Preiser [15] which are directly adopted and carried over in Table 2 (3a). The building delivery cycle begins with strategic planning. Individuals, groups or organizations determine their medium or long-term needs based on the mission of the organization, or individual objectives, and goals and targets for the project, as well as feasibility studies in organizational contexts. For example, which rate of return, which market group, which image and external perception, and which budget and time plan should be achieved, are formulated during this phase. During programming, the goals and targets laid down within strategic planning are discussed between the client and programmer and systematically documented. Within the design phase, the requirements of the programming phase are translated into concrete and feasible technical specifications for construction. During this phase, planners, designers and engineers have the complex task of translating the goals set by investors, clients and/or developers into a more detailed set of performance targets. During construction it is important that the builders and contractors understand the performance requirements and targets and know how to turn them into a set performance requirements and targets for their suppliers. Throughout occupancy, the degree of performance-in-use attained by the project can be determined by building performance evaluations. These evaluations include assessing the level of user satisfaction by way of a number of different methods, including surveys, interviews, walk-throughs, participant observation, etc. Performance testing at the site (e.g. energy performance) can be conducted as part of facilities management, e.g. through monitoring energy use, water use, etc. As part of the building adaptive reuse or recycling, new performance goals are often established that are oriented to new standards and technical innovations and/or changing user demands because of changes in the way of working of the occupants, or because there is a change in tenant or occupant group altogether. The building might not be adaptable to new uses and hence will be deconstructed and recycled. This marks the end point of the cycle and also the beginning point of a subsequent building delivery and use cycle. Within these phases, there is a need for information specific to certain events in the life cycle of single buildings as also indicated in Table 2.

2.4 Functional classification of buildings

Performance demands can either be generally applicable or specific to use in a given situation. Use-specific requirements can be derived from the required or necessary functionalities of use. As a result, it is recommended to have a building classification system based on use or function. Most countries have a national system to classify types of building use or function. After having compared and contrasted three classifications, one from Germany[6] one from the United States[7] and one from ISO 6241-1984[8], the authors put forth the following suggestion of classification as listed in Table 2.

2.5 Levels of hierarchy and application

Performance can be required and measured for various levels of decomposition of the building and its system. Extending on [10] levels of hierarchy include property, built environment and environment, and society (see Table 2). Building performance relates not only inwardly but also to the outside world. This could be either considered within the neighbourhood i.e. the built environment, or society at large. In particular, buildings play a significant role in a sustainable development. [40] Discussions include whether buildings are to be accounted for within emissions trading. The performance concept can be applied at different regulatory levels, for example as agreements between states or on international level, included in national building regulations, applied or enforced by public authorities, used and applied by business or privately, all the way to the level of products and materials.

2.6 Work phases of performance approach and types of instruments

The essence of the Performance approach is to make the requirements for the project explicit “demand” so that the suppliers can respond with appropriate solutions “supply”. In each transaction, there is a demand-side and a supply-side.

The work for the Performance approach can be divided into the following sequence:

1. Make the Mission(s) / Objective(s) explicit. Formulate individual, organizational, and/or societal project goals
2. Translate goals into performance requirements, criteria, indicators of performance, targets and levels
3. Plan / realize (for new buildings as well as renovations)

4. Test the Performance results or evaluate based on criteria and indicators
5. Match Performance-in-use to requirements, i.e. compare performance requirements (targets and levels) and level of capability to perform of relevant features and characteristics of the property (during programming, design and construction, commissioning and occupancy).

Instruments - or tools – are used in several work phases including 2, 4, 5 and 6. Differences need to be made explicit between tools that: (a) support the formulation of performance requirements (including checklists, standards), (b) offer help in describing, calculating or assessing a building’s essential features and characteristics (i.e. during planning: planning and assessment tools; for existing buildings: questionnaires, test methods, use evaluations), (c) compare requirements and features of the design or the building with what is required, or with other buildings, and (d) translate the results of the performance assessment into a form of communication that is suitable for the various actors involved (e.g. a label, an energy pass/certification for buildings). Complex tools are capable of making the cited functions (a-c or a-d) available as a self-contained “tool-kit”. Some tools of b) and c) can also be used the other way around for a supply-oriented approach. In this case (c) would involve investigating which customers or target group would be suitable for an existing building. This concern is also relevant for planning and construction when it is intended that an existing building may serve several sets of users either at the same time or sequentially. The procedure necessitates that in the case of (a) above, several requirement profiles for various target and user groups (e.g. singles, couples, families, seniors, communes, disabled etc.) exist and are available. For instance within housing, a particular user group maintaining an individual lifestyles most probably will have other requirements regarding the living space than the next group. These very particular requirements have to be accounted for. Instruments or tools within (a) need to be developed so that actors on the supply and demand sides can communicate better with one another.

2.7 Summary

Table 2: Categories, stakeholders, life cycle stages and milestones, levels of hierarchy and levels of application for Performance Concept considerations

1. Major Performance Categories (authors' suggestion)	**2. Stakeholders** (authors' suggestion expanding on [6], [10])
• Functional Performance	• Investor / Owner
• Technical Performance	• Bank / Insurance Company
• Economic Performance (Real Estate and Cost)	• Designer / Planner / Engineer
• Environmental Performance	• Contractor / Builder / Product, Material, Service supplier
• Social Performance	• User / Occupant / Visitor / Public
• Process Performance	• Facility Manager / Property Manager
	• Regulators / Authorities / Society
3a. Life Cycle Phases (quoted from [15])	**3b. Specific events within whole life cycle** (authors' sugg.)
• Strategic Planning	• Investment
• Programming	• Financing
• Design	• Appraisal
• Construction	• Leasing / Letting
• Occupancy	• Purchase / Sale
• Adaptive reuse / recycling	
4. Types of occupancy (authors' suggestion expanding [6],[7],[8])	**5. Levels of hierarchy** (authors' suggestion expanding on [10])
• Commercial	• Society
• Cultural	• Environment
• Education & Research	• Built Environment
• Governmental & Public	• Property
• Health	• Building
• Industrial	• Sub-systems (e.g. Interior Spaces and building sections)
• Leisure & Entertainment	• Elements and Building Components
• Religious	• Products and Materials
• Residential	**6. Levels of Application** (authors' suggestion)
• Sports & Recreation	• International
• Technical infrastructure & Transport	• National
• Other Buildings	• Communal / Public
	• Business
	• Private

Table 2 provides a summary of the different areas of Building Performance under consideration - as briefly discussed in the above section. There are interrelationships between all areas. Such a system of categories can serve as a basis for reviewing existing methods and tools which will be introduced in the following sections.

3. Description of situation and development in selected global areas

3.1 North America – Canada and the USA

3.1.1 Canada

a. Canadian National Building Code: Canadian Objective-based Building Codes

Canada is one of the countries furthest advanced in adopting a new set of National Building Codes. Since the mid-1990s, Canada proceeded with a major consultation program and analysis of the current National Building Codes. Work is based at the National Research Council Canada – Institute for Research in Construction (NRCC-IRC)[9]. [19],[20],[21],[22],[23]

b. Functionality and Serviceability of Whole Buildings and Facilities: Methodology created to match Requirements and Performance / Serviceability (ST&M)[10]

This work was started in the late 1980s, at the request of the Federal Government of Canada. The methodology and an application to the "Office Building Type" were published by 1993[11] [13]. They became ASTM [12] standard in 1996 and ANSI standard in 1997. [12] The methodology is currently an ISO Committee Draft, CD 21933-1.

ASTM Technical Committee E06 on Performance of Buildings, formed in 1946, with current membership of approximately 850, has jurisdiction of over 170 standards at this time. One of several technical subcommittees within E06 is subcommittee E06.25 on Whole Buildings and Facilities, started in 1981 as a Task Group and officially designated as a Subcommittee in 1983, to develop and promote standards for the description, measurement, prediction, improvement and management of the overall performance and serviceability of buildings and building-related facilities. A major part of the work in support of this subcommittee is based in Ottawa, Canada, at the International Centre for Facilities – Centre International d'Etudes de la Gestion des Bâtiments et Installations[13]. The related standards are under the jurisdiction of ASTM E06.25, and the newly formed ISO TC59 / SC14 / WG10. [24],[25],[26]

c. Performance Based Information and Documentation

Based at the University of Montreal, Professor Colin H. Davidson has been working on a design-manufacture-build decision process model that traces the Performance-related steps and the information required at each step. His interest in quality and performance started in the early 1970s, and he, and his work, can certainly be noted as pioneering in this subject matter. Work is based at University of Montréal[14] – IF Research Group. [27]

d. Performance Based Information for the Management and Maintenance of Built Assets

The Institute for Research in Construction (IRC) of the National Research Council Canada (NRCC) is Canada's construction technology centre. Established in 1947, IRC provides research, building code development, and materials evaluation services. Working with partners, IRC addresses issues that have a large economic impact, assisting industry to innovate and develop technologies that are safe, durable and cost-effective.

In particular, IRC has created the following:

- An object model for maintenance management of roofing systems as a case study to demonstrate the applicability of a proposed generic framework for integrating the maintenance management of built assets. The framework consists of five sequential management processes: (1) Identify Asset, (2) Identify Performance Requirements, (3) Assess Performance, (4) Plan Maintenance, (5) Manage Maintenance Operations. The model builds upon the Industry Foundation Classes (IFCs) (Releases 2.0 and 2X) to define object requirements and relationships for the exchange and sharing of maintenance information between applications. Maintenance Management is one of the defined projects within the Facilities Management (FM) domain committee of the International Alliance for

Interoperability (IAI). Several extensions are proposed to the IFCs including the representation of functional requirements, assessed condition of objects, inspection and maintenance tasks, and libraries of non-specific information. Usage scenarios are provided to illustrate the use of the model to carry out selected processes.

- The Building Envelope Life Cycle Asset Management project has identified enabling technologies critical to attaining its objectives of optimizing the service life of building envelope components and systems. The preliminary investigation concentrated on the need for close links between user requirement modelling and those of service life prediction, life cycle economics, maintenance management, and risk analysis. The integrating tool is product modelling. Although there is a rich history in the field of user requirement (performance concept) modelling; however to date, there is no conceptual model and little vocabulary to represent the concepts described in much of this research and related standards. In addition, the language in the applicable ISO standards needs refinement and more structure. Work is based at National Research Council Canada – Institute for Research in Construction (NRCC-IRC)[15] [28], [29].

3.1.2 The United State of America

At the time that this paper is being written, the government of the United State of America (USA) includes probably the largest set of organizations that are implementing a comprehensive Performance based approach program from the very top. In 1993, Congress passed a law titled "The Performance and Results Act, 1993". It requires all government agencies to prepare Strategic Plans that also include a Performance Plan [30]. In 2004, the Executive Branch of the US government issued an Executive Order detailing how government assets will need to be managed, including reporting on key performance indicators on a quarterly basis [31].To implement this Executive Order, US government agencies are assembling the current measures of performance that are used to assess the performance of their constructed assets. A report has just been published by the Federal Facilities Council [32] detailing those Key Performance Indicators (KPIs).

In the US government, performance-based contracting is mandatory. The USA Federal Acquisition Regulations [33] state that: "Performance-based contracting means structuring all aspects of an acquisition around the purpose of the work to be performed, with the contract requirements set forth in clear, specific, and objective terms with measurable outcomes as opposed to either the manner by which the work is to be performed or broad and imprecise statements of work."

In order to comply with the Act of 1993 and the Executive Order of 2004, agencies of the US Government are starting to apply the same "performance" approach to the logistics that support their operations, including all capital assets. As an example, in a recent paper, Hammond et al report on how "The US Coast Guard is fundamentally changing the way it manages its resources in response to a policy shift with a focus on performance results." [34]. In order to respond to this shift, the US Coast Guard is applying the ASTM standard methodology described earlier [11] [12] [13] [25] [26] for defining demand, assessing supply, and analysing the gap between requirements and capability to perform to its logistic support functions [35]. This methodology and the new sets of scales created for the US Coast Guard, together with the results from a Facility Condition Index, a Mission Criticality Index, and other sets of criteria, are used to prepare a gap analysis for each asset considered and to set priorities for project funding.

The US General Services Administration (GSA) is moving in a similar direction, and also requesting that, as of 2006-01, the software applications that it will use should be IAI – IFC compliant (International Alliance for Interoperability – Industry Foundation Class). This again will have a major impact on how building information and data will be classified and organized.

3.2 Europe / Germany

At the European level, two directives have been passed that are close in content to the performance approach: the Construction Products Directive (93/68/EEC) and the Energy Performance of buildings directive (2002/91/EC). Currently, it is suggested that the term 'integrated building performance' be used for an overall system to describe and assess buildings as part of CEN standardization activities. This would include the categories technical performance, environmental performance, cost performance and comfort and health performance. At the national level, some individual countries have already included the performance approach in their building codes, including Great Britain, the Netherlands, Sweden and Norway [1]. Spain has been following these developments for some time and is looking into the possibilities of introducing it. [4]. France was initially very active in the performance approach development and applied it for civil works but rarely for buildings. Up to now it has not been legislated within the country. [4]. Currently, research institutions (CIB, CSTB, VTT, BRE, TNO, etc.), professional institutions (RICS, RIBA, BNA, etc.) and universities in Europe (Karlsruhe, Salford, Delft, etc.) are working with the performance approach and already have developed performance tools and instruments. Selected examples of existing tools and instruments are listed in section 4 and are classified into a proposed typology.

In Germany, the term performance is not widespread. As described in detail in [3], the term quality, as used in Germany, can be applied in the same sense as the performance approach. This is congruent with the principles of ISO 9000. Standards that regulate the tendering of construction services (anchored in VOB/A, Section 9 since 1973) [36] offer the possibility that investors/owners and contractors/builders agree by contract on construction services based on performance-based contracting and tendering. This is an alternative to the present detailed description of construction services to be performed. In Germany, there is an intensive discussion underway on the possibilities of implementing the principles of sustainable development in the building industry. A series of instruments are available such as guidelines, checklists, data processing tools and building passports[16] for buildings. There is furthermore an ongoing debate in the field of functionality for housing, residential buildings and surrounding living environments concerning the question of how differentiated lifestyles and living aspirations can be translated into requirement profiles for specific user groups. Instruments in this regard are being developed at the University Karlsruhe.

3.3 Japan

In Japan, the New Office Promotion Association of Japan (NOPA) was established in June 1987 as a core organization for the promotion of new offices. In this regard, the most important contribution by NOPA is that of a survey that was undertaken to formulate *recommended minimum standards* for the planning and design of new offices in Japan. This set of standards is collectively referred to as the NOPA New Office Minimum Standard, and has as its objectives, to improve and enhance both workplace environmental quality and workplace impact on productivity. It must be emphasized that the focus area of NOPA, together with the NOPA New Office Minimum is specifically *office environments* and not general building performance as might be suggested by other approaches discussed in this paper.

Since its inception in May 1995, the NOPA New Office Minimum has become the primary means of evaluating and improving office environments in Japan in terms of both workplace environmental quality and impact on productivity. During this time the Standard has been used extensively to evaluate, acknowledge, and reward innovation in office environments by giving awards to new offices that have achieved high standards. The achievements of the NOPA New Office Minimum Standard can be better understood and appreciated when considering the fact that the NOPA New Office Minimum is not legally enforced, but adopted and adhered to voluntarily by organizations based on their commitment to ensure employees' health, comfort, general well-being, and safety. As such, the NOPA New Office Minimum Standard has become known as an objective indicator of the state of new office environments in Japan [37].

The NOPA New Office Minimum [38] consists of a total of 22 standards in 10 categories. The standards are formulated on a minimum-requirement basis and where possible, expressed numerically. The Standard focuses on the general work area, but where necessary, also includes ancillary spaces, which contribute to the performance and accomplishment of work in the office environment. Topics covered by the NOPA standards range from the general characteristics of the office environment, to recommendations pertaining to the provision, use, and optimization of resources such as office automation (OA) equipment, desks, chairs, and filing, and finally, criteria regarding Facility Management (FM), managerial aspects, considerations regarding environmental awareness and employees' health, comfort, well-being, and safety [37]. In order to determine the evaluative capability and comprehensiveness of the NOPA Minimum Standard, research by Le Roux et al. [39] subjected the NOPA standards to a comparative analysis with the IBPE tools. Results of the comparative evaluation indicated that both evaluation tools include similar criteria that focus on evaluating the performance of basic environmental aspects such as lighting, acoustics, and indoor temperature. Since the standards included in the NOPA New Office Minimum are formulated according to minimum-requirements as apposed to optimum performance, the ability of the standards to identify specific problem areas and evaluate aspects of good design, is regarded as low. Compared to the IBPE tools, the New Office Minimum includes additional evaluation topics which are related to managerial and operational aspects, quality of office furniture, and employee health, comfort, well-being, and safety. Although topics related to managerial and operational aspects are generally not considered as impacting directly on a facility's environmental performance achievement level, an assessment of these topics provide an indication of how employees perceive the environmental quality of the office, as well as their level of job satisfaction.

An important difference between the two evaluation tools was the absence of occupant questionnaires from the NOPA New Office Minimum. This necessitated on-site investigative-level surveys by surveyors in order to determine aspects pertaining to the performance of the specific office environment. As illustrated by the performance evaluative approach of the IBPE tools, feedback from occupants provides additional information regarding the specific environment's performance achievement. As such, the NOPA New Office Minimum focuses specifically on assessing an office environment's performance (serviceability), rather than actual user-requirements. In this regard, the approach taken by the ASTM Standards on Whole Building Functionality and Serviceability is exemplary in terms of evaluating both user-requirements (functionality profile as per the ASTM Standards) and facility performance (serviceability profile as per the ASTM Standards). The evaluation methodology of the NOPA New Office Minimum therefore allow for only bottom-line evaluations to be undertaken. Recommendations based on these evaluations subsequently are generic in nature and would suit the majority of organizations and facilities.

4. Survey of selected instruments (tools, standards, checklists, set of indicators)

Selected instruments and tools were examined according to areas of application and type (as discussed in section 2.6.) and are depicted in Table 3. Table 3 shows that the instruments can be applied within one or more areas but not in all. The reason is that they often were developed for a specific application at first, with more functions and applications pursued later.

Table 3: Typology of selected performance instruments and tools

Application / Instruments / Tools	A: Performance Requirements[A]	B: Performance Measurement[B]		C: Performance Assessment[C]	D: Performance Communication[D]	
		New Build.	Existing Build.		Non-rated	Rated
1a. Codes and Regulations[a]	Building Decree[1]					
	CPD (93/68/EEC)[2]					
1b. Standards[b]	ASTM standards[3]					
		NOPA M/S[4]				
2. Checklists / guide lines	Healthy Office[5]					
	SIA 112/1[6]					
	Guideline SusCon.[7]					
3. Calculations / algorithms[c]		LCA-Tools[8]				
		LCC-Tools[9]				
			SAP 2001[10]			
4. Measurements[d]			Accounts[11]			
5. Questionnaires[e]			CBE (IEQ)[12]			
	DQI[13]					
6. Building descript./passport[f]					Build. File[14]	
7. Labels / Certificates				ECOHomes[15]		
8. Integrated Tools[g]		EcoProP[16]				
		LEGEP[17]				

Index: fully applicable | partly applicable | not applicable

A Formulation of stakeholders' requirements
B Description, measurement and evaluation of newly planned or existing buildings
C Matching stakeholders' requirements with building delivery
D Communication of non-rated or rated results

a National building codes and regulations (mandatory)
b International or national standards (non-mandatory)
c e.g. LCA, LCC or energy rating tools etc.
d e.g. reading of meter, energy consumption reports, charts
e e.g. expert walkthrough, occupancy and use analysis
f e.g. plans, specifications of materials, technical components
g e.g. software based complex tools

1 Dutch Building Decree ("Bouwbesluit"); Ministry of Housing (VROM) (NL)
2 Construction Products Directive; Council Directive 93/68/Eec of 22 July 1993; Council of the European Communities; http://europa.eu.int/
3 ASTM Subcommittee E06.25 on Whole Buildings and Facilities, within ASTM Committee E-6 on Performance of Buildings (USA)
4 NOPA Minimum Standards (JAP); http://www.nopa.or.jp/index_p6.htm
5 Healthy Office Guide („Gesundes Büro"); Hypovereinsbank (GER); www.hvbgroup.com
6 Nachhaltiges Bauen Hochbau; SIA 112/1 (CH); www.sia.ch
7 Guideline for sustainable construction („Leitfaden Nachhaltiges Bauen"); Ministry of Transport, Building and Housing (BMVBW) (GER); http://www.bmvbw.de/
8 Life Cycle Analysis (LCA) tools
9 Life Cycle Costing (LCC) tools
10 Standard Assessment Procedure (SAP) for Energy Rating of Dwellings, DTLR (UK); www.bre.co.uk/sap2005/
11 Accounts of energy costs for space heating, water heating and lighting indicating gas, electricity and water consumption
12 Occupant Indoor Environmental Quality (IEQ) Survey; CBE (US); http://www.cbe.berkeley.edu/RESEARCH/survey.htm
13 DQI Design Quality Indicators; (UK); http://www.dqi.org.uk
14 Building File ("Hausakte"); Ministry of Transport, Building and Housing (BMVBW) (GER); http://www.bmvbw.de
15 ECOHomes/BREEAM; BRE (UK); http://products.bre.co.uk/breeam/ecohomes.html
16 EcoProp ; VTT (FIN) ; http://cic.vtt.fi/eco/ecoprop/english/EcoProp_brochure.pdf
17 LEGEP ; University Karlsruhe (GER) ; http://www.legoe.de

Some of the tools from table 3 were analysed further with respect to the criteria considered in each. Table 4 presents a long and diverse list of criteria. However to differentiate the criteria, they are characterized according to intention and time-point when they most likely will apply.

Table 4: Comparison of performance criteria regarded within selected instruments

characteristic	**Performance Criteria** n used to describe requirements (earlier / qualitative) o used to measure and evaluate decisions (later / quantitative / measured)	**ASTM Standards (US)**	**EcoProP (FIN)**	**SIA 112/1 (CH)**	**Guideline Sustainable Construction (GER)**	**NOPA Minimum Standard (JAP)**	**Functional Performance category**	**Other Performance categories**
n	Access control and security (staff, personnel, public)	X	X					X
n	Accessibility (users incl. disabled, service/maintenance personnel)	X	X	X	X	X		
n	Acoustics	X	X					X
n	Aesthetics, image, appearance, spaciousness	X	X			X		X
n	Air quality (freshness, contaminants, smoke, exhausts, ions)	X	X	X		X		X
n	Air supply and Air Conditioning (HVAC)	X	X		X	X		X
o	Availability of data / information for building service	X						X
n	Availability of services and amenities near site	X	X					X
n	Availability, support and potential of technical systems and installations (power & water supply, lighting, alarms, IT, HVAC)	X	X			X		X
n	Biodiversity		X	X	X			X
o	Cleanliness (site, building, interior spaces, fittings, fixtures)	X						X
n	Cultural, historical, recreational value of site		X					X
o	Demolition and disposal costs		X					X
n	Durability, maintainability, condition of components, finishes & fixtures	X	X		X			X
n	Duration of usability/operation of building services and amenities	X						X
n	Energy efficiency	X	X	X	X	X		X
o	Energy rating compliance	X			X			X
n	External costs			X				X
o	Failure response, efficiency of building service personnel	X						X
n	Fire safety		X					X
n	Flexibility / Adaptability / Variability	X	X	X			X	
n	Floor load capacity	X	X					X
n	Heat loss and solar gain (windows + external walls)	X			X			X
n	Impacts on environment (emissions, effluents, hazardous waste)		X	X	X			X
n	Integration of building on site and surroundings			X	X	X		X
n	Interaction and rest spaces	X		X			X	
n	Investment costs		X		X			X
n	Involvement, participation and identification (building/processes)			X	X			X
n	Land use intensity			X	X			X
n	Lighting and glare	X	X	X		X	X	
o	Maintenance costs	X	X	X	X	X		X
o	Management of building service	X	X					X
n	Monitoring of technical systems / installations	X	X					X
n	Noise protection (internal, external)	X	X	X	X	X		X
o	Operation costs	X	X		X	X		X
n	Precautions for safety in use (accidents and injuries)	X	X	X		X		X
n	Privacy	X	X					X
n	Provisions for natural catastrophes (radiation, earthquake, flood)		X			X		X
n	Reliability of building systems	X	X					X
n	Replenish- and availability of resources			X	X			X
o	Resource consumption (power, water, fuel, materials, space)	X		X		X		X
n	Reuse / Recycle / Deconstructability	X		X	X	X		X
n	Service Life (building components and technical systems)	X	X	X			X	
n	Signage, way finding and orientation	X	X	X			X	X
n	Site (size, location, condition, landscaping)	X	X					X
n	Site accessibility + safety (transportation)	X	X	X	X			X
n	Site amenities (parking, recreational spaces)	X	X					X
n	Space clarity (separation, demarcation, zoning)	X	X	X			X	
n	Space efficiency, capability and capacity (e.g. internal circulation)	X	X		X	X	X	
n	Space suitability and usability (size, mix, layout, location)	X	X		X	X	X	
n	Thermal conditions (temperature, movement, humidity)	X	X					X
n	Thermal protection of envelope (in winter and summer)	X	X	X	X			X
o	Unit costs (power, fuel, space, services personnel)	X						X
n	Users-controllability of building systems (temperature, air, lighting)	X	X			X		X
n	Vibration	X		X				X
n	Views to outside, Daylight	X	X	X	X			X
o	Waste management	X		X	X	X		X

5. Proposed criteria within a framework

There are two major scientific groups developing and working on approaches for describing and assessing overall building performance. On the one hand are those who have applied the approach to the project delivery process. More recently, there has been a whole new movement focused on overall sustainable development. The latter group recently adopted the concept of environmental performance of buildings. The authors appreciate that the performance concept applies to any set of requirement topics. Therefore they suggest that a possible combination of major categories may have the following structure:

Table 5: Performance Categories and Criteria - Overview

1. Functional Performance	
• Space suitability and usability (size, mix, layout, location) • Space clarity (separation, demarcation, zoning) • Space efficiency, capability and capacity (e.g. internal circulation) • Service life (building components and technical systems) • Noise protection / Acoustic performance	• Flexibility / Adaptability / Variability • Site (size, location, condition, landscaping) • Site amenities (parking, recreational spaces, etc.) • Availability, support and potential of technical systems and installations for processes (power & water supply, lighting, alarms, IT, HVAC)
2. Technical Performance	
• Load bearing capacity (*structure* / floors) • *Stability* • Maintainability, condition of components, finishes + fixtures	• Durability • Reliability • Thermal protection of envelope / Heat loss and solar gain
3. Economic Performance	
a) Cost Performance • Investment costs • Design & Planning costs • Building and Construction costs • Operation and Maintenance costs • Demolition and disposal costs • Unit costs (power, fuel, space, services personnel) • *Total cost of ownership* • External costs	**b) Real Estate Performance** • *Value* • *Income stream* • *Return on investment*
4. Environmental Performance	
• *Energy performance class* (Energy rating) • Resource consumption (power, water, fuel, materials) • Impacts on environment (emissions, effluents, hazardous waste) • Land use intensity	• Biodiversity • Reuse-/ recycle-/ deconstruct-ability • Replenish- and availability of raw materials Energy intensity for production and construction • Renewable energy
5. Social Performance	
Comfort and health • Thermal comfort (temperature, movement, humidity) • Air quality (freshness, contaminants, smoke, exhausts) • Views to outside, Daylight • Lighting and glare • Acoustics • Vibration • Signage, way finding and orientation • Privacy • Cleanliness (site, building, interior spaces, fittings, fixtures) • Interaction and rest spaces • Controllability of building systems (temperature, air, lighting) • Duration of usability/operation of building services and amenities • Availability of services and amenities near site	**Security and safety** • Accessibility (users incl. disabled) service/maintenance personnel) • Access control and security (staff, personnel, public) • Fire safety • Precautions for safety in use (slipping, tripping) • Provisions for natural catastrophes **Identity** • Integration of building within site and surroundings • Cultural, historical, recreational value of site • Involvement, participation and identification • Aesthetics, spaciousness, image, appearance
6. Process Performance	
• *Effectiveness and efficiency of design, planning and construction process* • Management of building service • Monitoring of technical systems / installations	• Availability of data/information for building servicing • Failure response and efficiency of building servicing • Waste management

Index:	carried over from Table 5	*added by authors*	~~regarded as inappropriate~~

Table 5 represents how the criteria carried over from Table 4 can be sorted into the major categories from Figure 1. Some criteria can be allocated to more than one category, depending on how they are viewed and interpreted. It remains important, however, that the criteria, as recorded within the system, should be cross-referenced, if they are included in more than one category. The criteria can be used to describe requirements at an early stage within the decision-making process (i.e. during strategic planning and feasibility studies) for new buildings and are then mostly of qualitative nature, as well as at the different phases of the Life Cycle of the facilities. The criteria can also be applied to measure and evaluate the decisions taken through measurements on existing buildings.

6. Conclusions

The authors note that buildings are increasingly traded in an open and global market place e.g. within open-end and closed-end real estate investment funds. When looking from the stock market investors' perspective, highly aggregated information, which makes a building's performance in one part of the world comparable to another, would be useful to better assess the worth of an organization and of the real property it uses. In particular, measuring its rental space would be a first step in consistently reporting the value of a real estate portfolio. [41] Such information is also useful for portfolio management by organizations operating in many markets and by organizations with a need to allocate funds to building projects according to priorities that are clear, transparent, traceable and auditable. Next to highly condensed information, there is the need for transparent information. Especially financial institutions, following the guidelines of Basel Capital Accord II[17], will scrutinize building performance (termed property rating) carefully and evaluate financial risks connected with the property investment. This development makes building performance evaluation more important than before. There seems a greater need to measure, evaluate and communicate a building's performance in a standardized manner, requiring collaboration between all involved in the entire building process.

Endnotes

1 Performance-Based Building Codes - International Council for Research and Innovation in Building and Construction (CIB)
2 Performance Concept in Building - International Council for Research and Innovation in Building and Construction (CIB)
3 Performance Based Building Network - International Council for Research and Innovation in Building and Construction (CIB)
4 ASTM Subcommittee E06.25 on Whole Buildings and Facilities, within ASTM Committee E-6 on Performance of Buildings
5 This work was created by the International Centre for Facilities, Inc., and partially funded by the government of Canada (Public Works and Government Services Canada)
6 Types of Building Use, Building Classification Catalogue BWZK of 02.12.1982
7 http://www.masterplanning.com/
8 ISO 6241-1984 (Performance standards in building – Principles for their preparation and factors to be considered)
9 http://codes.nrc.ca/
10 http:/www.icf-cebe.com
11 http:/www.icf-cebe.com
12 http://www/astm.org
13 http://www.icf-cebe.com
14 http://www.umontreal.ca
15 http//www.nrc.ca/irc
16 The building passport – also often described as the building file or building dossier – is a document which describes the essential attributes and characteristics of a building.
17 http://www.bis.org/bcbs/aboutbcbs.htm.

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Decision Support Toolkit (DST) – a step towards an Integrated Platform for Performance Based Building (PBB)

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Abstract

The additional Performance Based Building (PeBBu) Thematic Network task on decision support toolkit (DST) has reached its final stage. PeBBu aims at combining fragmented knowledge in the area of Performance Based Building in order to build a systematic approach towards innovation of the building industry and applying user requirements throughout the building process. End-users, policy makers, building industry and regulatory communities are closely involved in this development in order to facilitate dissemination and implementation of research results.

The objective of PeBBu DST task was to collect promising decision support tools into a toolkit and to test the most promising ones in selected PeBBu Domains. This paper represents the DST content, sums up the testing results from and summarises key findings from passionate discussions amongst different performance based building experts.

The task included successful test sessions in October at Delft and in November at Porto facilitated by VTT Building and Transport (Finland) and University of Reading (U.K.). They outlined future PBB development needs in the industry and in different customer segments. The problems of the construction and real estate cluster have been pointed out to be insufficient customer orientation and on this matter PBB offers extremely promising foundation.

The most challenging part of the task, outlining the future development directions for PeBBu, is finally introduced as a PBB Framework describing present stage, next steps and future challenges.

Keywords: Decision support tools, decision support toolkit, performance based building, post occupancy evaluation, check lists, requirements management, quality function deployment, multi criteria decision making, design structure matrix, iBUILD, interoperability, PBB framework

1. Introduction

1.1 Performance Based Building

Performance Based Building (PBB) is defined as ‘the practice of thinking and working in terms of ends rather than means’, as applied to building and construction [1]. Concept provides a flexible and technically non-prescriptive framework for building design and construction. Its application consists of translating human needs (functionality, comfort, etc) first into functional and then into technical performance requirements, implementing them within a regulatory framework through codes/ standards/ specifications and enable the construction of buildings that provide long-term satisfactory performances. Application of the performance concept is gaining worldwide interest and acceptance. It is becoming increasingly recognised as a possible basis for globalisation and synchronisation of the trade of building materials. [2]

The PBB concept applies itself to the constructed asset planning, programming, design, procurement and construction, life cycle management and operation, and to building regulation control. The application will provide substantial benefits to both the end-user and to the participants in the building process. Performance Based Building [2].

1.2 PeBBu Thematic Network

PeBBu thematic network aims at combining fragmented knowledge in the area of PBB in order to build a systematic approach towards innovation of the building industry and applying user requirements throughout the building process. From this, white spots and a coherent future research agenda can be derived. End-users, policy makers, building industry and regulatory communities are closely involved in this development in order to facilitate dissemination and implementation of research results. The Network especially stimulates investments in research that may be expected to produce practical recommendations for the adoption and application PBB throughout the building industry and in all phases of the building process [2].

1.3 DST Objective

The additional Performance Based Building (PeBBu) task on decision support toolkit (DST) has reached its final stage. The objective was to collect promising decision support tools into a toolkit and to test the most promising ones in selected PeBBu Domains. This paper represents the selected tool, sums up the testing results from and summarises key findings from passionate discussions amongst different performance based building experts.

The task included successful test sessions in October at Delft and in November at Porto facilitated by VTT Building and Transport (Finland) and University of Reading (U.K.). They outlined future PBB development needs in the industry and in different customer segments. The problems of the construction and real estate cluster have been pointed out to be insufficient customer orientation (The European Construction Technology Platform, ECTP, Vision 2030 Report [3]) and on this matter PBB offers extremely promising foundation. The most challenging part of the DST task, outlining the future development directions for PeBBu, is finally introduced as a PBB Framework describing present stage, next steps and future challenges. Task produced two final reports [4].

2. DST - Selected Tools

Seven promising decision support tools supporting owners’ and clients’ decision making are structured under value management, value engineering and process management. Selection based on applicability and interoperability covering building life cycle phases. Toolkit contains Post Occupancy Evaluation (POE), Check Lists (CL), Requirements Management (RM), Quality Function Deployment (QFD), Multi Criteria Decision Making (MCDM), Design Structure Matrix (DSM) and iBUILD tool (Figure 1). Colours and numbers indicate applicability priorities.

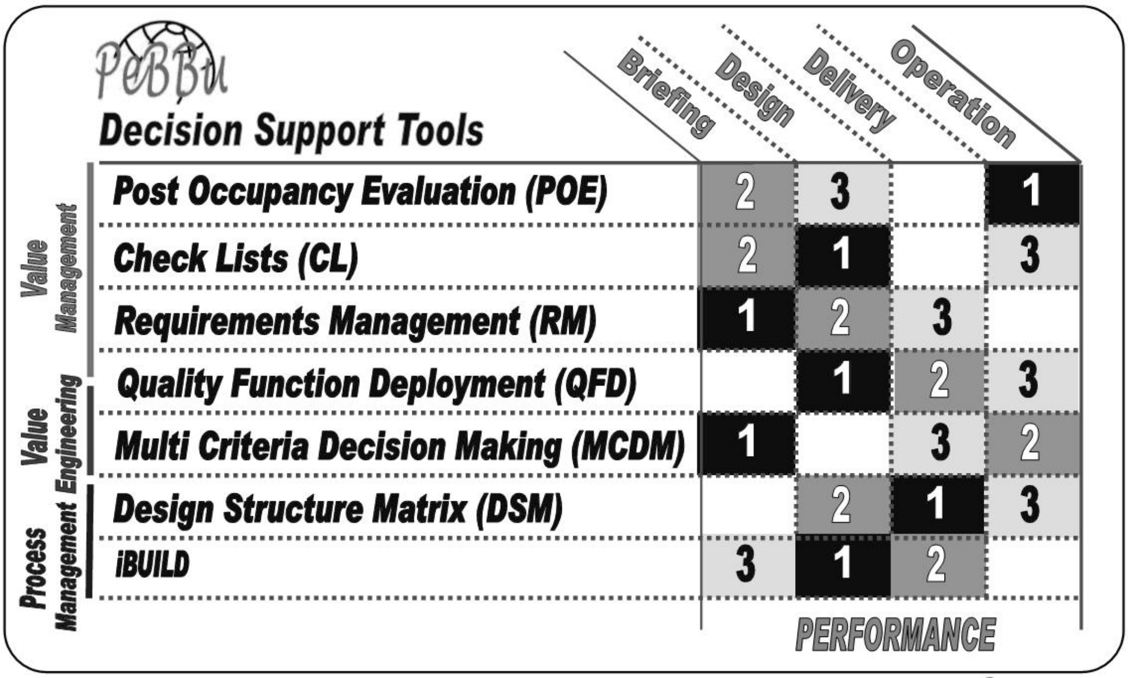

Figure 1: Selected PeBBu Decision Support Tools and their primary applicability.

2.1 Tool Introductions

POE process evaluates buildings in a systematic and precise way after few year of usage. Valuable input to the early project stages can be drawn from use and operation. Method is formal and comprehensive examination and evaluation of a building using methods aiming to study the effectiveness of designed environments from human user perspective. The results are presented traditionally as building strengths and weaknesses and method is often repeatable because of systematic and adaptive nature. Nowadays many of the studies in occupied buildings exploit POE. It's also clear that the operation phase should have more attention than earlier phases due to its financial importance. [5, 6, 7, 8, 9]

Complex nature of buildings is understood better through **Check Lists.** Those have been exploited in other tools but unfortunately performance based approach is still lacking universal classification. There are various CLs existing such as CIB Master Lists (supports performance) [10], ASTM (functionality and serviceability) [11], GBC (sustainability) [12], LEED (sustainability) [13] and VTT ProP® (conformity and performance) [14]. Main objective of Check Lists is their two-way connectivity to other tools, especially in setting performance objectives and making design decisions.

Requirements management ensures that we know what the customer really wants and also verifies that these objectives are met. Purpose is establishing a complete, consistent and unambiguous requirements specification [15]. Performance of the building should be defined comprehensively before the actual technical solutions get defined [16, 17]. Requirements and design are strongly linked; changing nature should be remarked also in tools. EcoProP software for systematic requirements management (see Figure 2) from VTT Building and Transport was introduced [14]. Software helps to set systematically performance objectives, to view requirement profiles, to estimate LCC and LCA impacts and finally to form an appendix to design brief on performance objectives. A data base tool includes pre-set requirement levels paving the way for applying by various users in different building types.

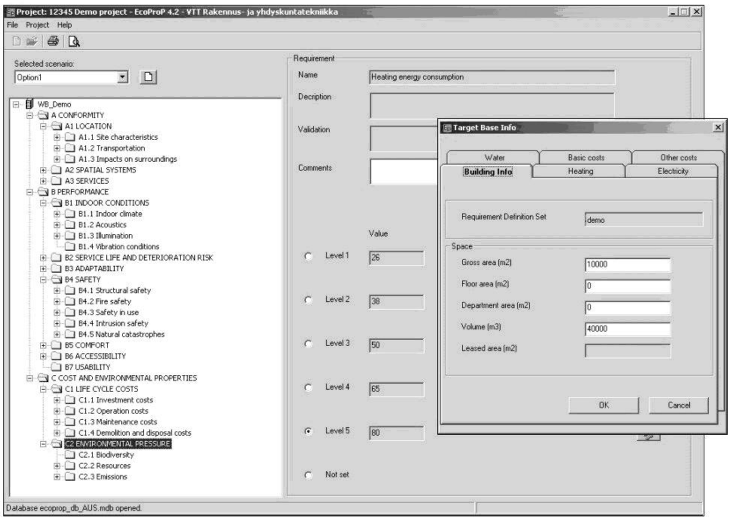

Figure 2: EcoProP software for systematic requirements management.

Quality Function Deployment (QFD) helps to represent performance objectives and priorities and then increases transparency on evaluate how and whether these objectives can be met [18, 19, 20]. Both of the contributors, Reading and VTT, introduced own solutions. ***Reading QFD tool*** is targeted to managing large amount of data, includes systematic priorities setting and assessment against benchmarks. ***VTT's QFD ProP*** is lighter combination and therefore exploited also in PeBBu DST Domain testing with integration to EcoProP.

Multi criteria decision making helps to structure discussion on objectives, relations and alternatives and synthesize those to model. Theoretical approach bases on value tree analysis. Widely recognised Analytical Hierarchy Process (AHP) uses the pairwise comparisons to solve multiple attribute problems, but when number of variables increases procedure becomes time consuming [21, 22]. Web-HIPRE comprises different MCDM tools (including AHP) used for prioritisation and analysis [23].

Design Structure Matrix (DSM) is a compact and clear representation of complex system and capturing method for the interactions/interdependencies/interfaces between system elements [24, 25]. Visual relationship matrix reveals key information flows and sets simultaneously targets to process analysis and re-engineering. It used for finding the optimal order of tasks and defining product architecture (modularity and interfaces) and forming teams in large organisations. In case the problem exists it helps also to solve inconsistencies. There is many commercial applications available for DSM.

Last tool, **iBUILD** from TNO Netherlands enables market driven product development in housing by modular intelligent parametric designs for houses [26]. It highlights client possibility to make changes and still exploit lower process of mass-production. Computer applications help the non-professional client in decisions and visualise consequences. The system streamlines the building process through the generation of drawings, support in selection of building products from suppliers, to derive plans and schedules, to prepare procurement and production orders.

3. DST Test Results

Leading theme in testing was interoperability; work is started with one tool and continued with other, as Figure 3 illustrates. Requirements management tool EcoProP and QFDProP exploiting house of quality matrices formed the interoperable platform for testing.

The first trial was conducted in Delft for Domain 2 (Indoor environment) led by Mr. Marcel Loomans (TNO) in October 2004 using a single family house that has been built in Kotka in Finland (case: Loiste). It highlighted innovative energy efficient steel frame solutions of high comfort. The test focused on managing the indoor conditions. The first DST workshop validated the test approach with a relatively simple housing case. The second test was arranged in Porto for all scientific PeBBu Domains in November 2004 using an industrial, adaptable and durable office building designed in the Netherlands (case: IDF Building). Slightly different approach was maintained in each domain. The leader of Domain 3 (Design), Mr. Dik Spekkink (Spekkink C&R), exploited the opportunity most effectively.

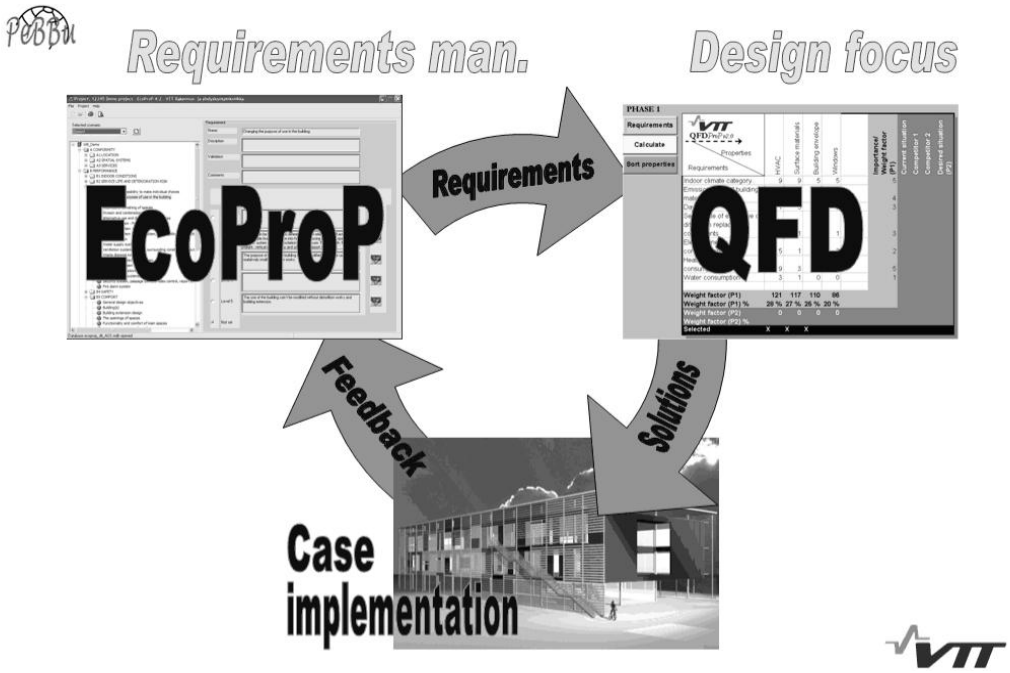

Figure 3: An example of integrated value management tools.

3.1 Case Introduction

Leading ideas of IFD building (Figure 4) development are: High adaptability, good indoor conditions, low environmental pressure, optimised running costs and value, representing corporate brand: serving image and innovative design and technical solutions [27]. It supports multiple layout solution inside the office floors, offering fixed solutions combined to flexibility in others.

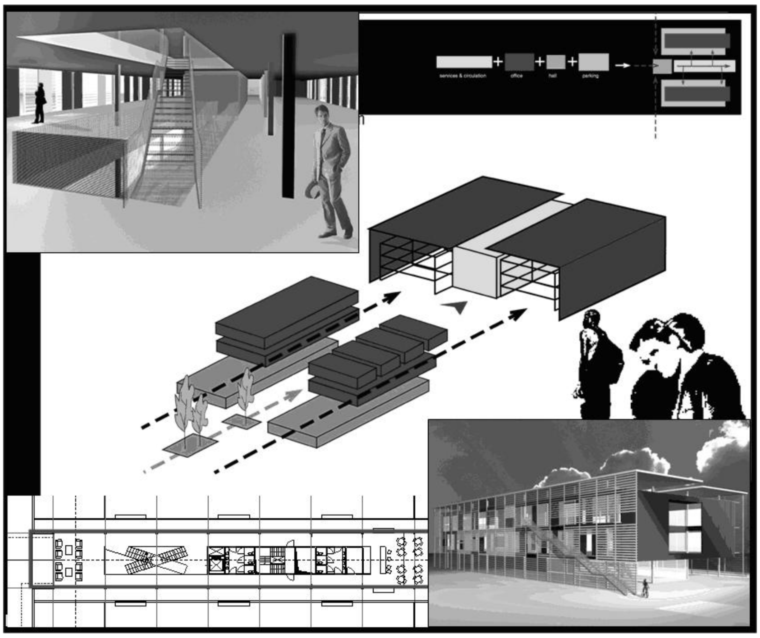

Figure 4: IFD Building.

3.2 Test Results

Performance objectives were captured with EcoProP that was remarked valuable aid in implementation the performance approach because the users are 'forced' to think their objectives before technical solutions. Experiences of implementations revealed that it increased discussion, commitment and teamwork. It also verified that the original needs were documented and ensured that essential requirements are not eliminated. Software was exploited in team session characterized by Domain members challenging each other. VTT ProP® classification was used to collection of performance requirements, following characteristics were remarked:

- Conformity
    - Location, spatial systems
- Performance
    - Indoor conditions (Indoor climate (FISIAQ), acoustics, illumination, vibration)
    - Service life and deterioration risk, safety
    - Adaptability, comfort, usability, accessibility
- Cost and environmental properties
    - Energy consumption (LCC, LCA calculations), water consumption
- Process
    - Process issues (Briefing, construction, quality assurance)

Lack of common performance classifications was remarked as an overall bottleneck for PBB. One possible baseline for this development is to study the content of VTT ProP® or other potential classifications. Certain inconsistencies were remarked but overall structure is performance based. One should also notice that different spaces need different requirements. Spaces have varied needs and defining their characteristics independently would offer better usability. It's vital for implementation to consider also requirement interrelations. This analogy isn't included at present EcoProP software, because of its complexity.

Decision support tools need also well documented manuals and supporting system. This means more reference information and exploitation of expert consultation. Systems shouldn't base on web-based information because URL addresses are considered to have their own service life and limited availability. Predefined lists pave way for rating objectives at a project level. Lists help to improve quality and simultaneously speed up process. They might also lead to incomplete solutions and in certain phases empty cells offer possibility to customisable solutions.

QFD was used to judging how well the original design criteria and technical solutions meet customer needs. Most of the attention was paid to following: indoor climate, material emissions, daylight, service life etc. Requirements were rated against properties (such as building envelope, windows) and these sorted properties were further considered in second phase finally describing characteristics of technical solutions. Results indicated that HVAC system was considered as critical part. Impact is stronger in offices than one family houses but Finnish building domain uses widely FiSIAQ indoor air quality classification; setting detailed recommendations for target values, design guidance and product requirements. It was clearly noticed that systematic procedures are needed to project meetings. Somebody has stated it clearly: "Client don't optimize the process, they hire a contractor to do that".

DSM can be used to organise tasks or workers and supported by Last Planner to help in validating execution possibilities. Potential use of DSM is in process analysis and risk assessment. DS tools enable proving of procurement practices benefits. Integration of tools is possible to by product model technology - requirements attached seamlessly to processes.

4. Conclusions

Observation 1: Traditionally the emphasis has been very much on design and construction. Experts from various countries and fields portrayed that yesterday's situation has been far too greatly production driven instead of being customer orientated. Situation in ICT tools was remarked to slightly better.

Observation 2: The emphasis is shifting from construction of facilities to operations. Discussions led to analysis that revealed emphasis is shifting to operation phase. Although the importance of design and construction is clearly understood the emphasis is predicted to shift towards operation model. The operation model is a starting point for new projects. According to ICT tools the change is intended to be stronger, because next generation tools are moving towards automation and use of standardized solutions.

Conclusion 1: ICT Tool development needs flow from Operation model to Requirements model. Value of facilities for user culminates to quality of requirements model. Therefore is strong need to develop the interface between operation model and requirements model; supported by seamless life cycle data management further to design and production.

Conclusion 2: Verification tools for proposed performance entities are needed. There is a need for verifying materialising of proposed performance entities by validation tools and appropriate applications are needed especially to design assessment.

5. Recommendations for the Future

The recommendations leading to better image amongst the audience and growing markets are structured to four main categories in Figure 5.

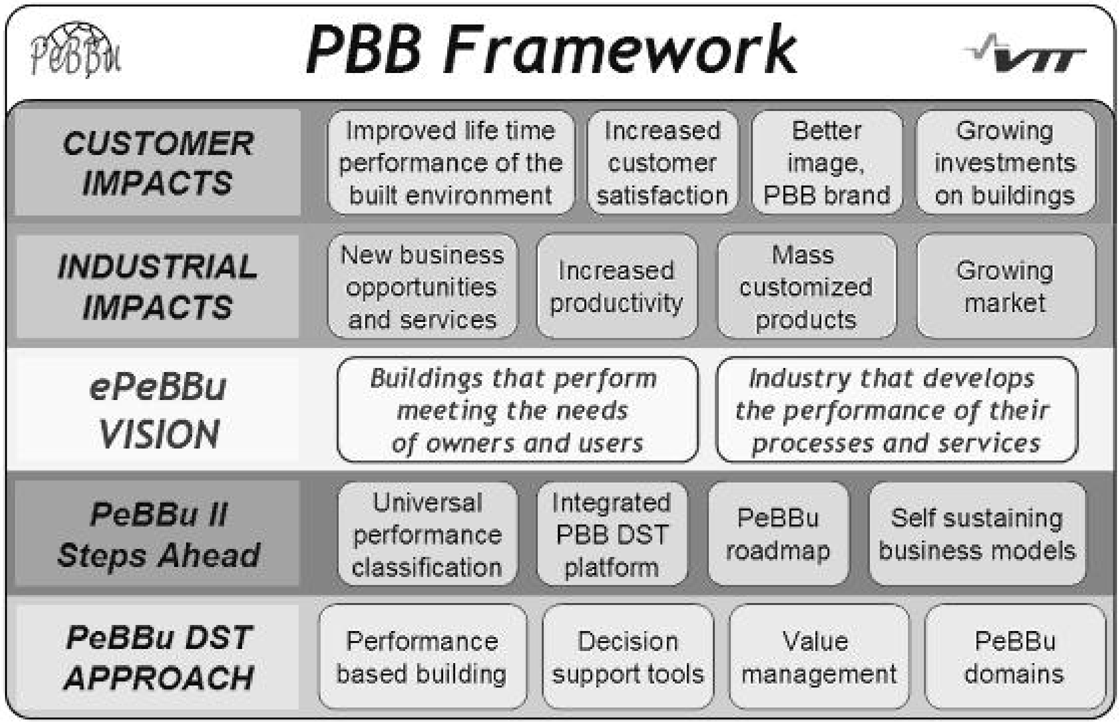

Figure 5: PBB Framework.

5.1 International Framework and universal Performance classification

***Problem**: No common means of true communication on performance properties exist.*

PBB needs a common vocabulary and a logical framework where different performance criteria can be referred to. A millennium version of a new CIB Master list could structure the high level criteria like the work was started in the CIB Compendium. The low level characteristics that may be material or technical solution dependent should be left open. A widely accepted generic performance framework would increase interoperability of tools and accelerate the diffusion of implementation.

Recommendation 1: Internationally accepted performance based building classification: a "PBB Master list 2006" (succeeding CIB Master list 1964, 1972, 1983 and 1993 editions).

5.2 Integrated platform with interoperable tools

Problem*: The support of performance management is scattered and number of isolated applications are unsystematically applied for sub-optimising individual solutions.*

It is evident that product model technology has developed to a level where it can enable the attachment of data from various phases to it, such as requirements management. This shift is intended to motivate developers towards consumer driven process.

Recommendation 2: a "PeBBu II" should be activated focusing on "ePeBBu Platform" and "PeBBu compatible applications" with pan-European true experts on board.

5.3 Value models, incentives and constraints

Problem*: Despite of the potential considerable benefits of PBB widely shared by researchers over the past decades very little, if any, change can still be observed in everyday practice.*

The reasons preventing the change must be identified and a credible path of progress with risk assessment is needed. A Roadmap describing the vision (or future scenarios) and needed action plan with relevant steps would show the way forward. Relevant landing points and indicators measuring the state together with listed incentives and barriers would complete the picture. Success stories (from outside or inside) or good practices could facilitate the implementation.

Recommendation 3: A cross-disciplinary study a "PBB Roadmap" objectively assessing various future scenarios could provide a discussion basis bridging various professions and disciplines.

5.4 Value adding whole life services

Problem*: It is still a mystery "current supply" could be transformed to meet "future demand".*

The industrial implementation of the PBB Roadmap needs methodological competence of forming value networks, establishing win-win-win rules and adopting customer oriented life cycle services. If the business models remain questionable no progress can be achieved.

Recommendation 4: Self sustaining profitable business models are needed to breed customer oriented networked life cycle services.

5.5 Information dissemination, regulations and education

***Problem**: People are lacking information and knowledge – it is a challenge to encourage innovation and development through regulations.*

Accessibility of information must be ensured. Value forming in the process enabling learning must be supported.

Recommendation 5: The development needs to be encouraged and assured at all levels.

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The PeBBuCo study[1]: Compendium of Performance Based (PB) Statements of Requirements (SoR)[2]

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Abstract

This paper presents the results from a study to develop a *Compendium of Performance based Statements of Requirements (SoR) for Constructed Assets*. The Compendium provides a source of information about SoR to those applying the approach to the procurement, delivery and Whole Life Cycle Management of buildings, facilities and other constructed assets. It is posted at the CIB PeBBu website. This website will be a place for gathering Performance Based (PB) Statements of Requirements (SoR). The Compendium is intended to provide examples of implementation of the "*Conceptual Framework for Performance Based Building (PBB)*". The Compendium and the PBB Conceptual Framework complement each other. Together, they provide the following: (a) what is the Performance concept and how it applies in the building and construction industry sector, why it is an important concept, how it helps customers and suppliers to better understand each other, and how it helps the suppliers to respond more appropriately to the requirements of their customers, (b) a template for data gathering about projects and sample case studies of building projects that have used a Performance based approach, in at least one major stage of the project cycle, (c) essential terms and definitions from both the "demand" and "supply" side, and (d) key bibliographic references. Successful application of a Performance based approach depends on closely matching user requirements (demand) with the performance of assets (supply). The Compendium is concerned primarily with how to communicate requirements, in the form of Statements of Requirements (SoR), which are prepared by customers, and Functional Statements, which appear in Objectives and Performance based codes. Key to the approach is that the requirements for a project define clearly and explicitly; what the building, the building product, or the related service is required to do, and not prescribe how it is to be constructed, manufactured or provided. The Compendium was developed in the context of a PBB Conceptual Framework for the whole life cycle management of facilities and constructed assets. The Conceptual Framework shows how links and matches can be made between user requirements (demand) and the performance of assets (supply). To illustrate how this works in practice, case studies are included based on real life applications of a Performance based approach in projects developed by RGD (Netherlands), and Defence Estates (U.K.).

Keywords: evaluation; evaluation criteria; client; compare, demand; functionality; match; performance concept; performance-based approach; performance based building; performance

indicators; serviceability; statement of requirements; suitability; supplier; supply; tools; user requirements

1. Introduction

The Compendium of Performance Based Statements of Requirements is intended to provide examples, based on case studies, and information that will help those applying the Performance Based Building (PBB) approach to the procurement, delivery and the whole life cycle management of buildings, facilities and other constructed assets [1] [2]. It builds on a previous study[3]. [3]

The PeBBuCo project has been developing documents in support of the main PeBBu project to confirm what is understood by a "Performance Based (PB)" approach as it applies to Building. The PeBBuCo team has prepared a "consensus based conceptual framework" for this project. This consensus has been significantly accomplished by presentations, papers and other communications with members of PeBBu. [4] [5] [6] [7]

2. Results from the PeBBuCo Study

The Compendium and the PBB Conceptual Framework complement each other. Together, they provide the following: (a) what is the Performance concept and how it applies in the building and construction industry sector, why it is an important concept, how it helps customers and suppliers to better understand each other, and how it helps the suppliers to respond more appropriately to the requirements of their customers, (b) a template for data gathering about projects and sample case studies of building projects that have used a Performance based approach, in at least one major stage of the project cycle, (c) essential terms and definitions from both the "demand" and "supply" side, and (d) key bibliographic references.

3. Compendium of PB Statements of Requirements (SoR)

Successful application of a Performance based approach depends on closely matching user requirements (demand) with the performance of assets (supply). The Compendium is concerned primarily with how to communicate requirements, in the form of Statements of Requirements (SoR), which are prepared by customers, and Functional Statements, which appear in Objectives and Performance based codes. Both the regulatory and the non-regulatory documents and process should include methods for validating, verifying and testing or assessing results. Key to the Performance based approach is that the requirements for a project define clearly and explicitly what the building, building product, or related service is required to do, and not prescribe how it is to be constructed, manufactured or provided.

The Compendium has been developed in the context of a PBB Conceptual Framework for the whole life cycle management of facilities and constructed assets. The Conceptual Framework show how links and matches can be made between user requirements (demand) and the performance of assets (supply). To illustrate how this works in practice, case studies are included based on real life applications of a Performance based approach in projects developed by RGD (Netherlands), and Defence Estates (U.K.).

4. What is PBB: A Conceptual Framework

4.1 The Performance Concept is simple

The clearest definition is contained in the CIB report #64. Gibson states that: "The Performance approach is [..] the practice of thinking and working in terms of ends rather than means. It is concerned with what a building or a building product is required to do, and not with prescribing how it is to be constructed." Gibson explains further that "In some parts of the building materials industry, performance specifications are known as "end result" specifications, while prescriptive specifications are known as "recipe" specifications. [8]

The prescriptive approach differs in the following way: "It describes means as opposed to ends, and [is] concerned with type and quality of materials, method of construction, workmanship, etc". [8]

4.2 Two Key Characteristics of the Performance Concept

4.2.1 Two languages: WHY&WHAT <---> HOW

The Performance concept requires two languages. On the one hand, there is a requirement (demand) and, on the other hand, there is a capability to meet that demand and perform as required (supply). The language of the client is needed on the demand side and the language of the provider is needed on the supply side. These are different and it is important to recognize this fundamental difference. (Figure 1)

4.2.2 Match and compare

Clients say, "At the end of the day, we need to be able to verify that what we get, at move in and over the life cycle of the facility, is what we asked for and paid for". [9] Evaluations and reviews as part of design, construction, commissioning, POEs, and benchmarking, need to refer back to explicit statements of requirements, otherwise they are based on perceptions, intuitions and guesswork. So, whether or not a "pure" performance approach is used, there is a need for making requirements more explicit and linking those requirements to the objectives for the project. Altogether, an evaluative stance is therefore useful throughout the Life Cycle of constructed assets.

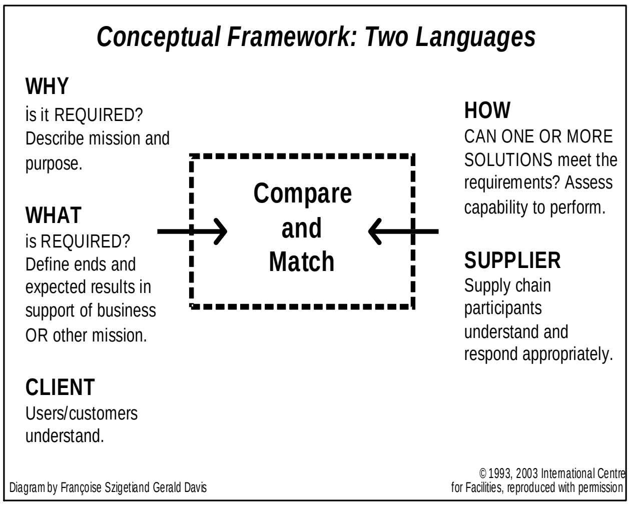


Figure 1: Conceptual Framework: WHY + WHAT and HOW – Two languages

4.2.3 It is not one or the other

Using a Performance based approach does not preclude the use of prescriptive specifications when the use of such specifications is more effective, efficient, faster, or less costly. When that is the case, it is useful to remember that prescription, whether in codes, standards, or specifications is implicitly based on past performance, and on prior experience, observation, tests or study. It is not likely that a facility will be planned, procured, delivered, maintained, renovated and used using solely a Performance based approach and documents at each step of the way, down to the procurement of products and materials.

5. Statements of Requirements (SoR)

Over the last decades, there has been a growing recognition of the need to consider buildings and constructed assets in the context of business, from the perspective of end users and as “means of production”, not only as overheads and cost centres. They are a useful support to business ends. Concepts such as Demand, Supply, Production, and Use, help us understand the relationships between building occupants and users (demand) and those who provide, maintain and operate the constructed assets (supply). Statements of Requirements (SoR) are, or should be, dynamic, not static, documents that include further details as projects proceed. They are part of a continuous process of communication between clients (demand) and project teams (supply).

SoRs, as understood in ISO 9000, include not only what the client requires and is prepared to pay for, but also the process and indicators that will provide the means to verify that the product or service delivered meets those stated requirements. They provide the information that anchors a Performance based approach. They are at the core of the whole life cycle management of facilities and provide the main basis for evaluations and other verifications when facilities are in use. They are the reference point for the commissioning process. Similar documents should be part of any procurement, as appropriate for the item being procured and the level of detail needed. SoRs are part of the audit trail. (Figure 2) [10] SoRs provide the documentation for overall projects, the link to the context and between demand and supply. (Table 1)

Asking questions to prepare a comprehensive SoR, and to support and document decisions, gives the provider team a clearer understanding of the project at hand. This can be a green field project or a renovation project of an existing asset. Assembling such a document usually leads to a more appropriate match between constructed assets and the needs of clients. Herewith is a sample of questions that the SoR might answer with regard to a building project as a whole.

- What is the building or constructed asset for? Why is it needed, and by whom?
- What mission(s) or objective(s) does it respond to and support? What task(s) does it need to facilitate? What kind of financing, ownership, and procurement route are most appropriate?
- What levels of performance are appropriate in this situation on specific criteria, and within what budget? What are the possibilities for trade-offs?
- What is the expected service life of the whole, and of components, parts, etc.? Are there some critical functions that require special support?
- What will it cost to run per year? What is the total cost of ownership?
- What are the milestones and deadlines? Are there any penalties for late completion?
- Does the client require that the building be designed to return energy to the grid? What level of labeling (e.g. BREEAM, LEED) is the client targeting?
- Will the activities housed produce hazardous waste, or other kinds of pollution? If so, what is required to deal with this situation? What impact will this have on the environment?
- What about the use of water and other resources, etc.
- What kinds of accessibility does this property require? Etc.

Table 1: WHY AND WHAT <compare> HOW: Context for Statements of Requirements

Hierarchy	WHY + WHAT	COMPLIANCE	APPLICATIONS Characteristics: Aspects Topics - Attributes
Society levels •global •international •national •regional •municipal •local	**Requirements levels** •Objectives / Goals / Targets •Functional Statements and other Requirements in user language •Performance Requirements in technical language •Operational Requirements	**CODES** •**Mandatory** --have legal authority •Minimum required (e.g. for fire, health, safety, etc.) **STANDARDS (external) / NORMS** •**Not mandatory** -- have legal authority ONLY if included in regulations •Either higher level of performance than Codes or additional attributes not covered by Codes and Regulations + Indicators of capability	**Building regulations and other applicable regulations** (e.g. environmental/green topics, clean air, accessibility, hazardous waste, water, etc.)
•Customers & stakeholders, •Groups of 'users' (inclusive of visitors and surrounding community)	Same as above	STANDARDS (internal) •**Voluntary** – internal to the organization or group •Either higher level of performance than Codes or additional attributes not covered by Codes and Regulations + Indicators of capability	**Statements of Requirements (SoR) (Project brief / Program)** **•Description of "user group/individual" / Mission(s) / Operations / Logistics support / resources, etc.** **•Environmental context** **•Time / Project milestones** **•Cost / Financial /Economics** **•Procurement route** **•Quantity** **•Functionality** **•Serviceability (Equivalent indicators of capability)** **•Service Life / Required condition** **•Security / Protection** **•Accessibility, Sustainability** **•Other attributes, etc.**
Individual/specific users (e.g. home owners, shopkeepers, hotel managers, etc.)	Same as above		
Evaluation, validation, verification / auditing	**Compare / Match Gap Analysis**	**Performance Test Methods (PTM), calculations, measurements, etc.**	**Key Performance Indicators Customer Satisfaction surveys, assessments, metrics, etc.**
•Infrastructure of Countries, Municipalities, Whole sites •Whole Buildings and Constructed Assets •Buildings, Building Systems, and Sub-systems •Components and Elements •Products, Services and Materials	**HOW** •---->From project and design analysis to constituent parts--->• •<---To whole constructed asset from constituent parts<-----•	•Prescriptive & PB Technical Specifications used on projects •Occupants' manual, O&M manuals, Building Systems Commissioning documentation, testing and controls software applications, etc.	•Acceptable solutions / Deemed to satisfy solutions •Specific solutions in given situations

Szigeti, F. & Davis, G., International Centre for Facilities (ICF) © 2001rev 2005. Based on a sketch by Foliente, G., CSIRO

Figure 2 [10] illustrates the Life Cycle Management of Facilities, and other constructed assets. It shows the Life Cycle from the perspective of those who manage, operate, maintain and use them, whether as owner-occupier or landlord. It also shows the key role of SoRs as the documents of reference throughout. User and stakeholder requirements define the objectives for the conditions and assets to be provided for a specific purpose, but independent of what solution might be chosen. They can be expressed in qualitative or quantitative terms. Performance requirements translate user requirements in more precise quantitative and technical terms, usually for a specific purpose. [8]

User and performance requirements need to be stated so that they can be measured and compared. Donna Duerk explains how a performance requirement should be written:

- address the outcome of an objective;
- be precise and unambiguous;
- be measurable
- be operational – be capable of being met;
- be positive and not negative;
- be capable of being used as a yardstick. [11]

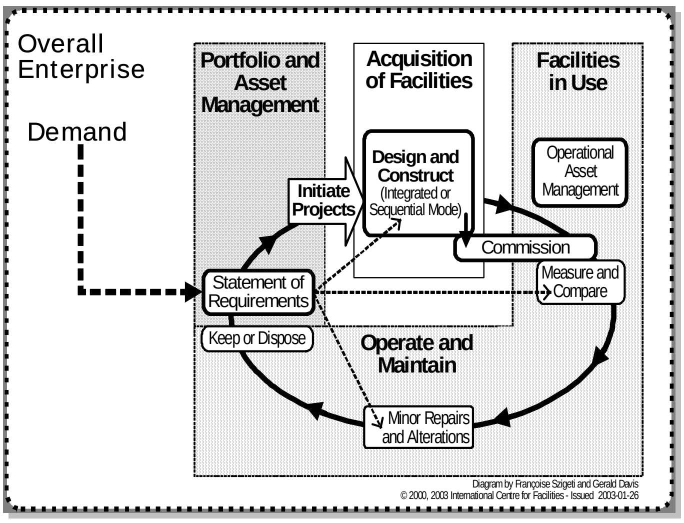


Figure 2: Statement of Requirements and the Whole Life Management Cycle of Facilities

6. Bringing non-regulatory and regulatory models together

The "Performance System Models" diagram [12] maps the flow of decision making from society and business objectives to construction solutions (Figure 3). This diagram brings together Non-Regulatory and Regulatory models. [6]

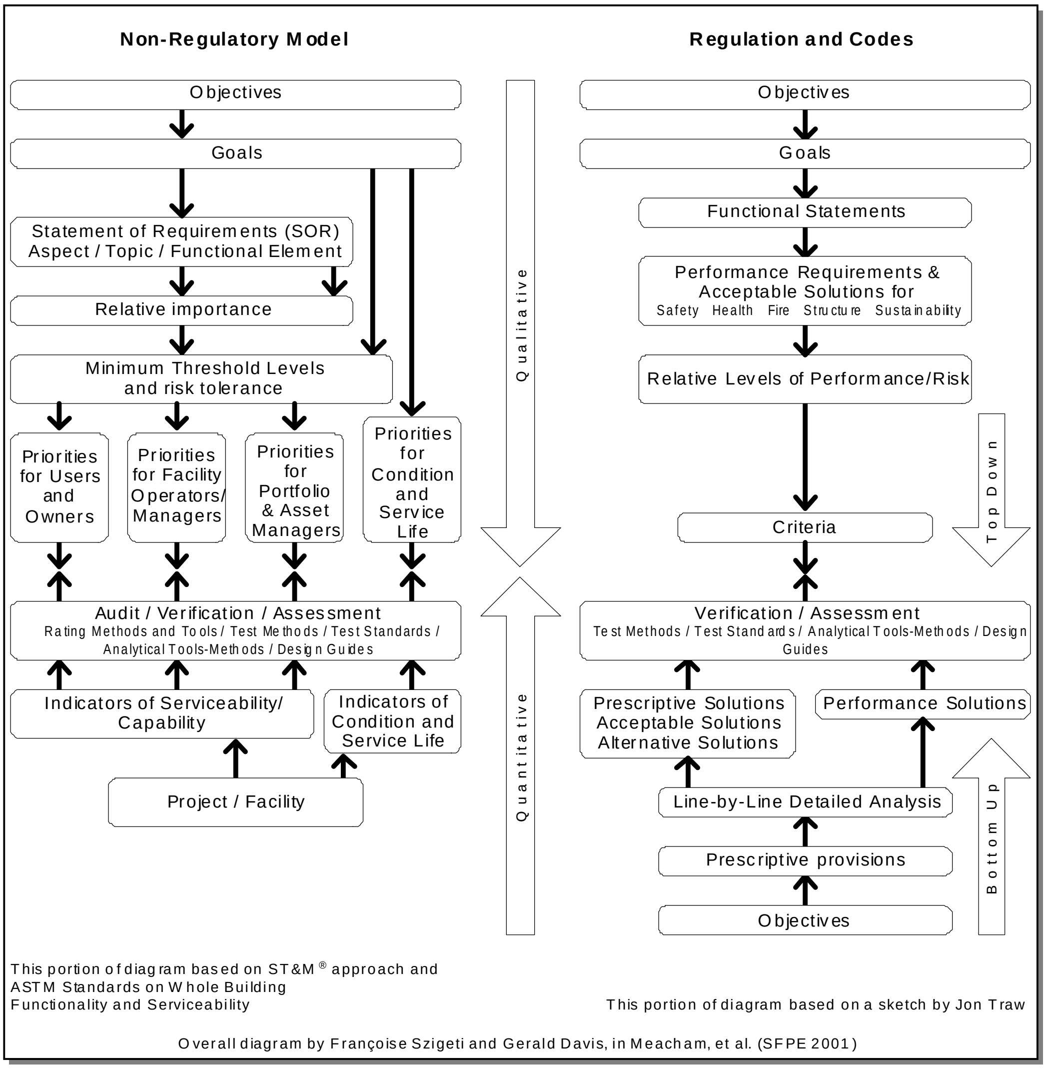


Figure 3: Total Performance System Models:A Framework for Describing the Totality of Building Performance (Source: Meacham et al. 2002)

The right-hand side of Figure 3 shows the requirements mandated by Codes and Regulations with the force of law. These are expressed in Functional Statements, and include for example, all design and construction issues that have a bearing on health and safety. The left-hand side illustrates what the client is willing to pay for. These requirements have no basis in regulation or law. The upper half of the diagram on the left shows client expectations, and the lower half shows the tools, measurement techniques and indicators which can be used to assess how well client expectations are met.

At the top of Figure 3 client expectations are expressed at their highest level first, then translated into Statements of Requirement, then sorted into priorities, then considered according to the priorities of the various interest groups. Starting at the bottom of the diagram the quantifiable and measurable performance indicators of the Project, Facility, or Asset, are mapped. The indicators begin with test methods, standards and tools, and move through indicators of serviceability, condition and service life that will be understood, measured and acted upon. Other aspects or attributes of the project can be defined and assessed in a similar manner.

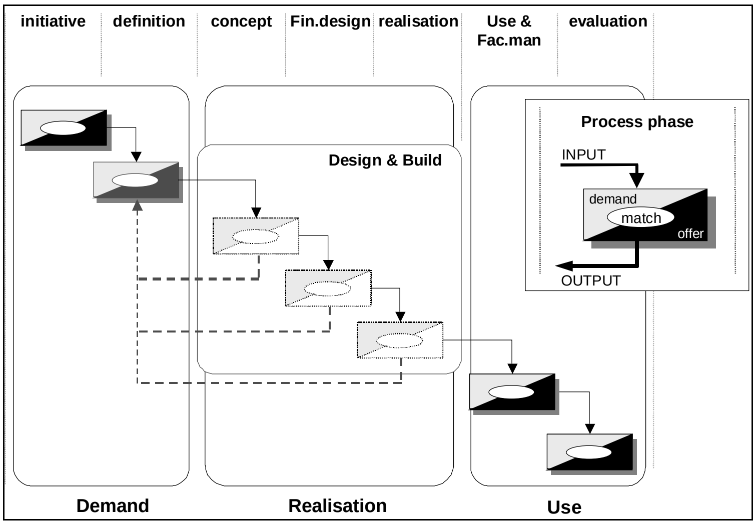
7. Summary of the Case Studies

The case studies assembled to-date and included in the Compendium cover major projects in the UK (the Building Research Establishment - BRE case study) and in the Netherlands (the Rijksgebouwendienst / Dutch Government Buildings Agency - RGD case studies). [13] [14] They were prepared separately, by individuals who are familiar with the evolving conceptual framework for SoR.

The BRE case study concerns two projects undertaken by the Ministry of Defence (UK), as part of their ongoing Prime Contracting Initiative. The first project dealt with is the “Building down Barriers” test project of the concept. The second is the pilot (Scotland) phase of the Regional Prime Contracting project. Prime Contracting is an example of an integrated project, where the design and construction phases of procurement are not rigidly separated, either chronologically or in terms of which party is responsible for each phase – in practice there is an integrated team comprising clients, designers, constructors and facilities managers within an integrated supply chain. Prime Contracting aims to deliver both capital improvements (new and refurbishment projects termed Core Works) and facilities management services (termed Core Services) across the full range of Defence property, including offices, barracks, training grounds, aircraft runways etc. The ultimate aim of the project is to provide an estate suitable to support the delivery of Defence services.

The Rgd case studies concern 4 projects where Rgd were involved on the client side. They range from a museum to a tax department. They are also examples of integrated projects, where both public sector and private sector performance requirements are involved. Three of the four projects are part of two major programs, one to build new Law Courts and the other to build new Tax Department Offices. [15]

As stated above, SoRs are a key link between demand and supply. Figure 4 illustrates the relationship of the Statement of Requirements to each of the transition points during the Design-Build delivery Process



Source: Oostinga, D., Compendium of PB Statements of Requirements, CIB 2005

Figure 4: Project & Life cycle TRANSITION points

Project 1. Summary: The Rotterdam "Wilhelminahof

The Rotterdam "Wilhelminahof" consists of a complex including: a Palace of Justice, the Regional Headquarters Tax Office, and a commercial office building. The overall goal for the project was to give the urban development within the area a boost for further investment. The urban revitalization was to be initiated by the "Wilhelminahof" building.

Procurement and tendering were based on functional requirements on the desired serviceability of the buildings. A DBFM-O (Design - Build - Finance - Manage – Operate) contract was signed in the transition from definition to design stage in public private contract with the Rgd. The bridge nearby over the river Maas and a subway station were part of a Public Private Partnership initiative. Within the building process, Performance Based Building focused on contracting at an early phase of the project and on performance specifications. The project documentation consists of a spatial statement of requirements, performance requirements, technical descriptions, prescriptive solutions, and functional requirements including organizational descriptions, general requirements and guidelines. The project was a mixture of innovative Performance Based Building and traditional aspects.

Project 2. Summary: Naturalis, National Museum of Natural History, Leiden

Naturalis is the newly build housing for the National Museum of Natural History in Leiden. By refitting the railway station site and by renewing and refurbishing the monumental "Pesthuis" (seventeenth century building, Plague house) a historical part of the city has been revitalized. The development of Naturalis is the result from a Public Private Partnership between the Municipality of Leiden, the Rgd and developer HBG Real Estate (formally known as Mabon). The project was owned by a private party at first and rented by the Rgd. Today the building is owned by the Rgd.

Projects 3 and 4. Summary: Central Building for Tax Department, Roosendaal and Heerlen

These two project are based on New build – Integrated contracts (development contract). Performance Based Building focused on contracting at an early phase of the project and integrating design and build capabilities through a development contract. Procurement and tendering were based on demand performance specifications which were the tender documents. Based on performance offer specifications, the projects were awarded to the developer. The basic contract between the Rgd and HEVO consisted entirely of performance specifications as they were formulated by the Rgd and the Tax Department.

8. Similarities and differences

8.1 Similarities between the UK and Netherlands examples

In each of the examples, there are a combination of performance based requirements and input / prescriptive requirements within the Statement of Requirements part of the contract documentation.

- Each includes an expectation that involving a wider representative group in developing the requirements for the project and the design concepts will improve the output / building.
- Each project has included some documentation which was standard / existing before the project, and which tends to be based on prescriptive requirements.
- Each project includes some element on maintaining / running / financing the project through a relatively long part of the life cycle post occupancy.
- Each has focused primarily on the earlier phases of the procurement process, and most emphasis and innovation appears to have been placed on how to communicate an SoR, rather than on checking responses.
- Each is expected to lead to efficiency and/or cost savings.
- Each is anticipated to support greater innovation.
- Each requires the parties to work with a high level of cooperation.
- Each challenged the skills on the client side in articulating their requirements in a performance based SoR.
- Each involved considerable cultural and process changes from typical procurement routes.
- Each involved a high level of collaborative checking of developing requirements and continual monitoring in the early stages of the project (the Cluster technique in the UK, the “pressure cooker” meetings in the Netherlands).
- Each involved some element of flexibility on the ultimate price to be paid for delivery of the project.

8.2 Differences between the UK and Netherlands examples

The key difference appears to be the role of the Architect – in the UK case study the term does not even appear, whereas it would appear that in the Netherlands the Architect expects to lead delivery of projects and determine key aspects of "good" design. An example would be in the case study on the Tax Department, where the Architect determined that glazing should cover the exterior of the elevator shafts despite the technical objections and consequent ongoing problem with cleaning (Section – Tax Department, item 4 - Lessons Learned).

The objective of capturing the expertise of facilities managers and gaining the cost and user satisfaction benefits associated may be difficult to achieve without a significant re-education process for Architects in the Netherlands. On the other hand, in the UK it is fairly apparent that very similar problems will occur. Future demand is often difficult to foresee. Unforeseen performance requirements for particular uses will be faced as within the Netherlands projects. In the UK Case Study, there seems to be a relatively weak Architectural contribution, which would appear to be the most appropriate skill set to resolve such issues.

From the Case Study reports, there appears to be more formal and developed techniques of risk management, value management and function analysis used with the wide project group in the UK, whereas these appear mainly to fall within the specialist knowledge of the Architect in the Netherlands. On the other hand, with the exception of the Building down Barriers project in the UK, the social and cultural challenges inherent in such procurement changes appear to be better addressed and understood within the Netherlands.

9. Concluding comments

This CIB PeBBuCo project was completed during the spring of 2005. Although the Compendium contains only a few case studies, some comments can be made, based on the findings of the case studies reported above.

Statements of Requirements have to be very carefully stated so that it is easy to verify that a proposed solution can explicitly meet those requirements.

High level statements of requirements need to be paired with indicators of capability so that design solutions can be evaluated before they are built in order to avoid misfits. In particular, the need for change has to be taken into account, since constructed assets have a long life, while uses and activities can change very rapidly.

When checking a design solution against the "explicit and implicit" requirements for a project, it is essential to test different ways that the spaces might be used in order to anticipate changes, otherwise a building, in whole or in part, can become very quickly unfit for the occupants.

Endnotes

[1] The study was commissioned by CIB (The International Council for Research and Innovation in Building and Construction) and completed during spring 2005. It was co-funded by the Rijksgebouwendienst (RGD, Government Building Agency, The Netherlands) and the United States General Services Administration (GSA), with in-kind contributions by the International Centre for Facilities (ICF, Canada) and the Building Research Establishment (BRE, U.K.). Team members were: Kathryn Bourke, Dr. Josephine Prior and Francoise Szigeti.

[2] Based on papers, documents and presentations prepared as part of the PeBBuCo study in support of the PeBBu project.

[3] This prior study was also commissioned and funded by CIB and co-funded by RGD.

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Performance-Based Framework & Applications for nD Models in Building and Construction

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Abstract

This paper presents a conceptual framework for the systematic application of the performance approach in the planning, delivery and management of built facilities. The full benefits of the performance approach are not always realised because of a lack of facilitating tools and platform that allow data interoperability and ease of practical and comprehensive application of the concept. Thus, this paper also describes the application of multi-dimensional (nD) models for performance modelling and analysis before construction (as virtual design & construction tools) and during the life of the facility.

Keywords: Performance approach, nD models, interoperability, virtual building, performance evaluation

1. Performance Based Building

The proactive and comprehensive application of the performance concept in the whole, or parts of the, process of procurement, delivery and management of built assets leads to: (a) better understanding and communication of client/user requirements; (b) better fit of client/user requirements & supplied facility; and (c) considerable flexibility in design solutions for building practitioners, which encourages innovation and cost-optimised solutions.

The performance approach works when desired outcomes of the process (e.g. time, quality & cost, return on investment, etc), product (e.g. in functional terms such as safety, health, amenity & sustainability) and/or services (e.g. maintenance and other facility management functions) are clearly described (as in a project brief), and achieved in the design, construction and management of the facility. But these benefits are not always realised because of a lack of facilitating tools and platform that allow data interoperability and ease of practical application of the concept [1,2].

This paper presents a conceptual framework for the systematic application of the performance approach in the planning, delivery and management of built facilities. It also describes the place and application of multi-dimensional (nD) models for performance modelling and analysis before construction (as virtual design & construction tools) and during the life of the facility.

2. IT-Based PBB Platform

A monolithic tool for a systematic and comprehensive application of the performance approach is impractical. There already is a preponderance of specialist tools available for aiding decision-making [2], and for performance analysis, design and assessment (some of these have been collected in a web-based compendium: www.auspebbu.org/page.cfm?cid=3).

A more acceptable approach is towards interoperable PBB decision-support tools. Figure 1 shows an IT-based framework for the systematic application of the performance approach in the whole life cycle of built facilities that allows different decision support tools and performance models to interoperate. As discussed in Ref [2], many of these tools have different uses and advantages.

In setting the performance requirements, there could be three sets of tools. The first is a performance requirements management tool (second from top in Fig. 1), such as EcoProp, which is used to set the performance targets for a project (either new or refurbishment) based on client/stakeholder goals and requirements. Ideally, this kind of tool should access a comprehensive database of performance indicators (top in Fig. 1). Depending on the type and nature of the project – identified early in the process – sets of indicators will either be made available or hidden from the performance requirements tool. Then, to set the priority ranking of performance targets for each project, a tool for performance requirements prioritisation (third from top in Fig. 1, e.g. a Quality Function Deployment tool for PBB) would be needed. This is important because finding solutions to meet required/specified performance attributes very often require performance trade-offs; a proper design/product solution to meet one set of attributes usually conflicts with another attribute.

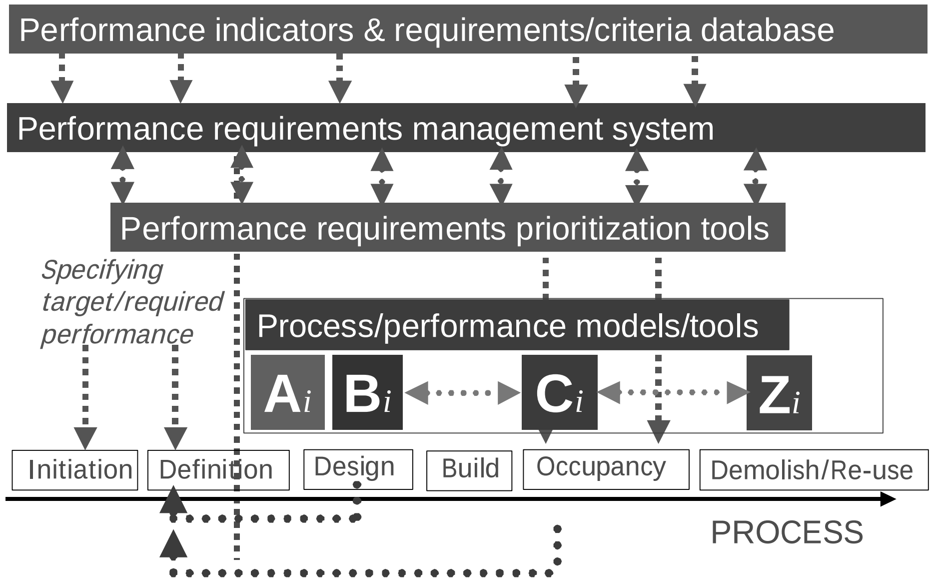

Figure 1: An IT-based framework for the systematic application of the performance approach in the whole life cycle

Then, to find solutions (in any stage from design, to construction or occupancy) to meet target requirements, various types of process and performance models are required (Fig.1). When used before construction, these tools are often called 'virtual building/construction' tools. Some of these can be integrated – via interoperability standards – into what is often called 'nD models'.

3. About nD Models

The terminology on n dimensions in describing construction systems seems to have first appeared around 2000 (e.g. [3]). The principle of extending the normal three spatial dimensions (called x, y and z) to the fourth dimension of time (i.e. x, y, z and t) follows the twentieth century physics approach. Suggested further dimensions included management attributes such as cost, schedule, procurement, materials, and accounting to allow project participants to visualize and manage the objects information [3]. Further dimensions such as colour and acoustics had since been added to the list. The concept of nD modelling in building and construction has culminated in an nD modelling roadmap [4].

But just what constitutes an additional dimension does not appear to have been made clear. Mathematical definitions focus on independent dimensions particularly linear independence, where the minimum number of dimensions required is most important in describing a system. In a mathematical sense, cost should not be an independent dimension because it is a function of all other attributes including time, i.e. cost can be calculated from the values of the attributes describing the constructed facility, e.g. size, type of frame, finish, how long it takes to build it and a series of constants representing cost per lineal or square metre. Many of the other suggested dimensions could similarly be derived from a smaller set of attributes, e.g. energy requirements, life cycle costs, acoustics and maintenance.

A proposed definition of nD modelling is that [5]:

'…nD is the parallel utilisation of building information for different analyses and evaluations …that will enable all stakeholders to experience the building, not just in a visual environment but in an information rich interactive system of all senses including acoustic (for ambient sound etc) and smell (to stimulate polluted environments)' etc. nD modelling '… is a new approach orientated to integrate existing and non-existing modelling approaches into a new way to deal with the different dimensions of a project from a predictive perspective.'

Such an approach to n-dimensionality focuses more on outcomes rather than the smallest set of independent inputs which enable a model to produce the performance measures required by different participants for each to quantitatively assess a design and understand the implications. In this usage, most "dimensions" cannot be compared to the basic spatial and time dimensions x, y, z, t and it can be misleading to do so. Thus, careful consideration of the characteristics which enable an attribute to be classed a dimension is required.

4. Conclusions

An IT-based framework for the systematic application of the performance approach in the whole life cycle of a built facility has been proposed. The place and use of decision support tools and nD models in such a framework were discussed.

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Section III

Performance Based Building Standards and Practices

Performance Based Building Regulations

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Abstract

The Building Regulations Domain of the Performance Based Building Network has collected relevant information about progress and difficulties in implementing performance regulations in participating countries. This paper discusses the experiences of the various countries as an amalgam. It then presents the leading research priorities in this field as they emerged from the domain discussions

Keywords: performance based building, construction regulation, code enforcement. .

1. Background

Domain 7 of the Performance Based Building Network has promoted international discussion and exchange of ideas and experience regarding the development, implementation, enforcement and support of performance based regulatory systems.

Building regulations typically seek to ensure the health, safety and well being of people in buildings. Toward this purpose they set minimum design and construction requirements. Building regulations may also promote other objectives, such as energy efficiency, serviceability, quality or value and facilitating the built environment to persons with disabilities.

Historically, building regulations were based on a prescriptive approach which severely limited the available solutions for compliance. Creativity and innovation were stymied or slowed as efforts were undertaken to adapt to or change the prescriptive regulations. These regulations also served to restrict and inhibit international trade.

Performance based regulations are predicated on the intended outcome and seek to encourage a variety of solutions for compliance. This promotes diversity and innovation in an industry that has traditionally been conservative. The performance approach also facilitates international trade. This applies to building products, processes and methodologies in the building design professions.

2. Objectives

Domain 7 of the Performance Based Building Network has collected relevant information about progress in implementing performance regulations in the participating countries. While discussion in the various domains tends to provide a favorable picture regarding performance based building, it may be a case of preaching to the convinced. The status reports in Domain 7 reflect an uneven picture of successes and frustrations in attempts to change the regulatory framework in the participating countries. While almost all of the countries are moving in the direction of performance regulations, most do not yet have a complete or fully integrated performance based regulatory system. In the absence of such a system, it is difficult, if not impossible, to implement fully the various aspects of performance based building.

The first objective of the paper is to provide a summary of those experiences. It includes:

1. Description of the regulatory system.
2. Scope of the regulations.
3. Enforcement and compliance.
4. Satisfaction level of the various practitioners.
5. What is perceived to be lacking or in need of enhancement (eg. gaps and barriers).

The second objective of the paper is to present research priorities as they emerged from the Domain discussions. Obviously there is a strong link to the gaps and barriers discussion of the status report surveys. However, in order for a subject to emerge as a research priority it had to result from the experience and needs of at least several countries.

The leading research priorities were as follows:

1. Verification methods to demonstrate that the required performance was achieved.
2. Risk informed regulations.
3. Methods for addressing acceptable or desirable levels of performance in existing buildings.
4. Creating a systems approach to performance requirements with quantifiable levels of performance.
5. Methods for evaluating the economic impact or feasibility.
6. Development of certification models and other means of approving designs and products.

3. Participation

Task members of the building regulation Domain hailed from the following countries: Belgium, Denmark, Greece, Hungary, Ireland, Israel, Lithuania, Netherlands, Poland, Slovakia and United Kingdom.

In addition, guests or observers from Australia, Canada, New Zealand and the United States participated in one or more of the Domain meetings. The participation and contribution of Australia was particularly significant as Australia operates a parallel network to the European Performance Based Building Network and several members were present at the various domain meetings.

Furthermore representatives from Australia discussed the findings of a productivity commission authorized by the Australian government to examine the contribution that reform of building regulation has made to the construction industry and to economic efficiency in that country. The Australian experience was particularly important as they have been pioneers in performance- based regulation.

Meetings, task members and guest represented a variety of organizations, academia, industry and government. They brought with them a range of professional backgrounds: architecture, code enforcement, engineering, legal, research and public administration.

4. Context

The Performance Based Building Domain is part of a thematic network funded under the European Commission's 5 th Framework – Competitive and Sustainable Growth. The program commenced in October 2001 and runs until September 2005. It involves networking various European and international stake holders to promote performance- based building, research and implementation.

Performance based building regulations need to be viewed within the larger general discussion of performance- based building. The concept put forth by the thematic network is that thinking about building and construction should be oriented to ends rather than means. "The basis of all building activity should be the performance of the building in use rather than the prescription of how the building is to be constructed". The other scientific domains of the network are life performance of construction materials and components, indoor environment, design of buildings, legal and procurement, innovation.

It should also be noted that there have been other international and regional cooperative efforts aimed at promoting performance based regulations. The most prominent of these is the Inter- jurisdictional Regulatory Collaboration Committee (IRCC). Furthermore, CIB has been active in this realm and sponsored a Task Group known as TG 37 which presented several papers at the CIB World Building Congress in Wellington, New Zealand in April 2001. This Task Group issued its final report in December 2004.

5. Scope of the Regulations

There are however distinctions between regulations and other aspects of performance based building. Performance based building is an encompassing approach related to the design, operation and maintenance of a building during its entire life cycle; essentially its general performance. The purpose of regulations is far more limited. Regulations seek to establish minimum standards of compliance. The generally stated purpose of most building codes is to ensure public safety, health and welfare insofar as they are affected by building construction. They typically regulate structural strength, adequate means of egress facilities, sanitary equipment, light and ventilation, and fire safety.

Just what else they regulate may vary in different jurisdictions. There is often confusion around consumer driven requirements that may or may not be authorized in the enabling legislation for a building code. In recent years the purview of many building codes has broadened, to include issues such as energy conservation and the needs of special population groups, particularly persons with disabilities. The extent to which, building regulations protect property or limit its potential damage is also a fuzzy issue. Their purpose is first and foremost life safety.

6. Description of the Regulatory Systems

As noted, all of the participating countries have some level of involvement with performance based building regulations. Obviously, there is a level of self selection as participation in the building regulatory domain was voluntary.

Members decided to undertake two surveys of the participating countries, both in order to understand the subtleties and differences between the regulatory systems, and to gauge and compare progress in implementing performance based regulations. The first survey was undertaken early in the network and domain activities, the second approximately four years later towards the conclusion of the project. The first survey had a limited response and the second is yet incomplete. An effort will be made to complete the survey and present its results at the CIB Congress in Helsinki in June and in the final report of the domain.

Nevertheless, various trends, conclusions and insights can be drawn from the incomplete survey results which are supplemented by country reports and discussions at the domain meetings.

6.1 An International Performance Based Building Code

Discussion was undertaken as to the possibility of a common shared international or pan- European performance based building code. The idea was resoundingly rejected for the foreseeable future.

Discussants noted the widely variable social, political, economic, administrative and legal contexts among different countries that make a common code impractical. Certainly there are also differences related to climatic conditions, building materials and building traditions. However, the intensity of the negative response may indicate additional underlying, less transparent, factors such as national, regional or even local pride and concerns about a loss of autonomy. All of this is not to say that the domain members did not see a broad basis for international cooperation. In fact there was full consensus on the benefits of cooperation and the opportunity to learn from the experience of other countries.

6.2 Prototypes for Performance Based Building Code Development

The Domain developed three prototypes for performance- based building code development that are described in the flow chart and survey form that follow. They constitute the second survey. Essentially for purposes of simplification and comparison, the pathways for performance based building code development were channeled into three prototypes that were designated cases A, B and C.

A represents those countries with the political will, the economic resources and the technical capacity to develop their own national model code.

B represents those countries at the opposite end of the spectrum in terms of very limited resources, internal technical capabilities, and perhaps lesser committment to performance based regulations. These countries are generally prepared to phase in various performance based building requirements into an existing regulatory system at a gradual and graduated pace.

C represents those countries that are prepared to revamp their building regulatory system to one that is performance based but from existing work carried out in other countries that can be adopted with minor adaptations or alterations.

All of the cases A, B and C involve some simplification and generalization and make various assumptions that obviously vary in the extent of their accuracy in the different countries. Probaby the most important assumption is that in all the cases key stakeholders in the building regulatory process have been engaged performance based regulations and are supportive. The point is that changing a building regulatory system requires a broad base of support. It can not be imposed top down as it will encounter resistance in the field. Neither will it evolve bottom up, as the field levels are unlikely to invest the time and resources or enlist the political clout to effecuate the change.

6.3 Country Updates

This section is based on reports at the domain meeting in Porto, Portugal in November 2004. Its content will be supplemented when the results of the second survey become available.

Table 1: Performance Based Building - Regulations Domain survey

1.	Preliminary Details:
1.1	Country Name: ______________________________
1.2	Other reference for building code:______________________
1.3	Last published edition (year): __________________________
1.4	Report submitted by: _____________ (name and e-mail)____________
1.5	Job title/Affiliation: ____
2.	Backround/Contextual Information:
2.1.	Brief description of code context in terms of 1.development 2 implementation. (please, attach a separate diagram as per the draft flow chart).
2.2	Brief description of social, political and legal context as related to above diagram (2.1).
2.3	Information regarding relevant administrative framework (who is doing what).
2.4	Information regarding future directions (adoptions, revisions, changes).
3.	Key Terms and Definitions (please include only keywords used in this from that need clarification` i.e. this is not for terms in the code itself).
4.	Code Structure and Contents
4.1	Structure of the code (diagram and/or tables).
4.2	Contents (outline as in table of contents, but with a short description of the main heading` e.g. 1-3 sentences).
4.3	Other technical notes.
5.	Key Lessons/Comments on Development and Implementation of the Code.
6.	Contacts and References
6.1	Contacts persons for further information and explanations.
6.2	Web sites for relevant information.
6.3	Other printed information that is available.

The Australian model will be discussed separately based on their extensive experience and a productivity commission study recently completed.

Belgium has a building regulatory system that is partially performance based. Local authorities continue to use prescriptive requirements. Performance based regulations are viewed as a means and not an end. Representatives see a combined system of prescriptive and performance based regulations evolving over time.

Hungary`s building regulatory system is primarily prescriptive. There is an energy survey requirement in place. That is performance based but not widely used. Representatives see a trend toward withdrawal from mandatory requirements.

Israel currently has primarily prescriptive requirements. However a government commission appointed after a social hall collapse recommended a substantial overhaul of the regulatory system including a comprehensive performance based code, and a process for evaluating new building technologies. Preparation of the performance based code is well underway. Fire safety requirements will remain mostly prescriptive.

The Netherlands also has a mixed building regulatory system that has been evolving over the past decade.

Poland has mandatory norms and standards, some prescriptive and others performance based that now constitute a building code of approximately 70 pages. Ordinances increase from year to year and the code grows.

Slovakia has a performance based code for the energy performance of building and is focusing regulatory efforts on CPD implementation.

The United Kingdom has an regulatory system based on 15 "approved documents" that are essentially performance based. "Deemed to satisfy" provisions are prescriptive but allow for equivalents. Experience shows private enforcers have resisted and complicated the use of performance based documents.

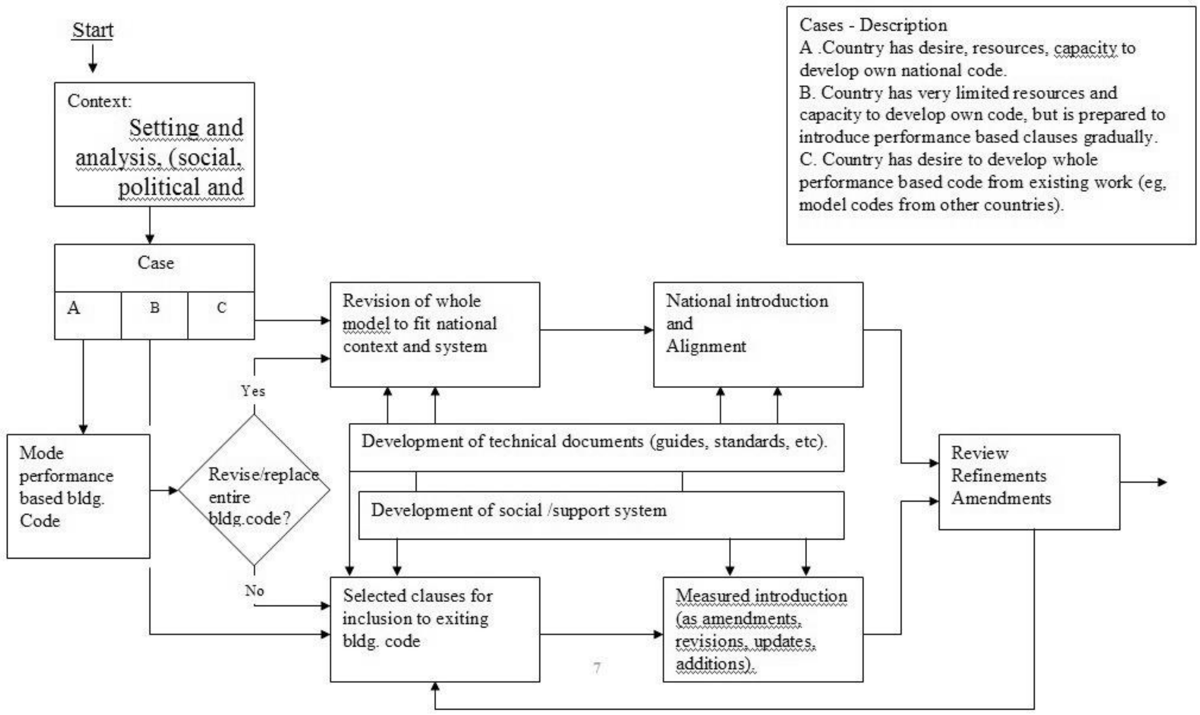

Figure 1: Possible performance based building code development prototypes for different countries

6.4 Reform of Building Regulation in Australia

In 1994 the Australian government established the Australian Building Code Board that vigorously pursued a performance based code. While the Board had no regulatory powers in and of itself, the code was adopted and used by the states and territories. This past year, 2004, the government of Australia undertook an extensive examination of the contribution of building regulation reform to economic efficiency and the construction industry.

The report found that the reform was successful in encouraging skill acquisition, reducing costs and encouraging and enabling innovation. It constitutes a strong endorsement of performance based building requirements.

However the report found that regulatory reform is far from complete. The report recommended:

1. further reducing, jurisdictional variations and reducing the, erosion of the codes uniform application by local planning decisions.
2. better articulation of the performance based requirements.
3. seeking ways to enhance local administration and enforcements.
4. reexamining the approach to property protection from fire.
5. better incorporating environmental requirements in the code.

As described in a PeBBu news article from February 2005 the report further found that:

The majority of the performance: requirements contained in the Code do not provide readily measurable outcomes nor specify verification methods. The standards are more accurately described as "principle" based, specifying broad, but not measurable, targets or objectives for building. For instance, for structural provisions, the Code does not specify precisely the loads that must be withstood by any building (such as wide-speed loads or dead loads)–rather it requires that the building must withstand "actions to which it may reasonably be subjected". This means it is not possible to judge whether objectives have been met and gives little guidance to building practitioners.

The report advocated resolving this issue and several other weaknesses in performance aspects of the code as part of the future work program. Overall the examination endorsed the performance based approach as "having the capacity to deliver significant benefits to the building industry and consumers".

7. Enforcement and Compliance

Enforcement and compliance are essential to the efficacy of any building regulatory system be it prescriptive or performance based. Generally, enforcement and compliance are based on the requirement for a building permit for any construction activity. It is the request for a permit, from the authority having jurisdiction, usually the municipality. That sets the system in motion. Plans are submitted usually as part of the permit request. Plans are reviewed and approved before a permit is issued. This is most often where the public and various building practitioners interact with the regulatory officials regarding the code and its requirements.

Once a permit is issued and construction begins there are likely periodic inspections in the course of the work. Once completed the construction is again inspected for full compliance of the work with the code before a certificate of occupancy or completion is issued. If work is not in accord with the code it must be corrected or done again. There are of course numerous possible variations on the process, but these are its essentials for almost all building work. Without a system of enforcement and compliance. The code is of little or no significance. Having said that, there are never the less wide differences in the extent and degree of enforcement in different countries and in some instances in different areas of the same country. In remote, rural and agricultural regions and areas where people tend to build

themselves rather than employ an architect, engineer and building contractor, municipalities are less likely to have effective code enforcement and compliance. Even in these areas public buildings, schools, large commercial buildings and factories are more likely to employ building professionals and will try to conform with some level of code compliance even if there is no enforcement system.

Other significant differences in enforcement and compliance revolve around the type or extent of work that is enforced. Wherever there is any enforcement it addresses first and foremost new construction. Here too there is the greatest relevance to the type of code requirements. The building regulation system likely also addresses additions, alterations and repairs to existing buildings. Generally maintenance work is not regulated but any other work involving change to exterior facades structural alterations or change to the electrical, plumbing, mechanical or fire protection systems of the building is likely to be officially regulated. The way in which minor work is defined and the extent to which it is regulated varies widely. Occasionally a functional distinction is whether the work is carried out by the owner/occupant or a building professional. Electricians, plumbers and heating ventilation and air conditioning contractors in places where these occupations are licensed are more likely to comply with permit requirement even though it is the owner occupants who are more in need of the supervision of their work and its code compliance.

Historic buildings are likely to be exempted from compliance with portions of the building code Performance based regulations are more likely to provide the flexibility that will enable compliance.

8. Satisfaction Level of the Various Practitioners

The issue of performance based versus prescriptive regulations pertains primarily to architects and engineers and to a lesser extent to building contractors. It also pertains more to large, unusual and sophisticated buildings than to residential, low rise, standardized building and construction.

Manufacturers of building materials and products are also relevant clients of the performance based code.

The satisfaction level of these practitioners with performance based regulations tends to vary. All desire fast building review approvals. The extent to which they themselves and the local regulatory officials are familiar and comfortable with the performance aspects of the codes is a function of time and willingness to learn and innovate.

In general there will be a segment of the building community that is resistant to change and will constantly pose the question:

"What do they really want?" Accordingly it is helpful that a new, performance based requirement be accompanied by deemed to satisfy provisions that are also prescriptive.

9. Gaps and Barriers

Given that the introduction of performance based regulations is often a gradual process, the new regulations may not address what some building professionals regard as the most important issues or those that most interest them, Similarly when they are partial or fragmented they can not comprehensively address all code requirement issues. There may be a need to merge performance requirements with prescriptive ones for various building systems or materials. Performance requirements by their nature often require greater effort by the practitioner to demonstrate compliance, In addition because they are new the performance requirements are less familiar and have not yet stood the tests of time and use by the various building professionals. Most of all it is difficult to verify compliance with performance based regulations, This last issue will be discussed more extensively in another section.

10. Leading Research Priorities

Each of the performance based building network domains was requested to recommend research priorities in their field. For the building regulations domain this proved not to be a difficult task. The experience of the various countries at various stages and with different degrees of success in implementing performance based regulations provided a convenient platform for the discussion of research priorities.

There was wide agreement on the importance and benefits of network and the potential for sharing the results of research in a number of areas. The subjects that emerged as research priorities were agreed upon based on the needs and wants of at least several of the participating countries:

These were as follows:

1. Verification methods to demonstrate that the required performance was achieved.
2. Risk-informed regulations.
3. Methods for addressing acceptable or desirable levels of performance in existing buildings.
4. Creating a systems approach to performance requirements with quantifiable levels of performance.
5. Methods for evaluating the economic impact or feasibility.
6. Development of certification models and other means of approving designs and products.

10.1 Verification Methods

The leading research priorities are heavily weighted toward verification. In order to verify compliance we need to be able to measure performance.

In this list of research priorities verification repeats itself with different, emphasis in four of the six priorities. Only risk informed regulations and methods for addressing performance in existing buildings address the objectives part of performance. Verification methods reflect a level of involvement and understanding of the performance approach that go beyond the declaratory stages about the advantages of the performance approach. Performance requirements, as noted, are usually stated as objectives. Objectives are generally qualitative.

However enforcement and compliance obligate verification that is quantitative. Herein perhaps lies the Achilles heel of performance based regulations; i.e. the difficulty in evaluating and ascertaining compliance. Qualitative matters, by their nature involve a large degree of subjectivity. Requirements as stated in building regulations can not tolerate fuzziness or lack of clarity. Ultimately the code official or building inspector needs to be able to make compliance determinations that are cleat cut, consistent and defensible under administrative review and legal challenge.

Quantitative requirement can be matched to qualitative objectives of performance based building regulation but it is difficult if the advantages of the performance approach are not to be lost in the process. Key performance indicators are a promising approach that may be able to bridge the gap. They need to provide simple yet coherent criteria that set the acceptable level or range of performance in ways that can be verified by tools at the disposal of the regulatory community. Generally key performance indicators involve benchmarking a given situation so that targeted performance can be assessed and compliance determined.

While technical performance criteria and verification methods have been proposed in a number performance based regulatory areas, particularly energy conservation, domain members demonstrated their keen interest in the expansion of verification methods as research priorities, the results of which can be shared internationally.

This is a significant challenge that will impact the future success of the approach.

11. Conclusions

Performance Based building regulations have broad support in the international arena. Different countries are proceeding according to separate prototypes and at varying paces in incorporating performance based regulations into their building codes. Most are not doctrinaire in their approach and are prepared to mix performance based regulations with prescriptive ones according to their understanding and experience as to which will best serve them.

While the idea of an international performance based building code was resoundingly rejected, there was full agreement regarding the advantages of international cooperation and shared research. The strongest future research priorities revolved around verification methods that provide quantitative indicators for qualitative objectives. International cooperation should continue and these and other research priorities should be aggressively pursued.

Acknowledgements

This paper was developed from discussions of the building regulations domain of the performance based building network and is based on the cumulative experience of the participants.

Special thanks are due to Dr. Greg Foliente, CSIRO, Australia who suggested and formatted the survey, Dr. Aleksander Panek, Warsaw University, Poland who co-chaired with me the Porto Portugal meeting and Mr. John Carson, CSIRO, Australia who presented the Reform of Building Regulation report by the Productivity Commission of the Australian Government at that meeting.

Performance-based procurement in Denmark

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Abstract

Although researchers, practitioners and authorities have for decades discussed the performance approach as a means of improving productivity, quality and innovation in building, the expectations have not been fully met. First, this paper will scrutinise the Danish model for performance-based building. This paper will stress that the Danish building legislation is by and large performance-based. Second, the paper will identify new trends and challenges to traditional procurement. It will be pointed out that especially integrated teams are challenging traditional procurement. Third, the paper will point out that strong elements of the prescriptive approach are present in professional practice. The paper will suggest that the relationship between prescriptive building and performance-based building is not a dichotomy but rather a continuum.

Keywords: Building Regulations, clients, legislation, procurement methods, contracting

1. Introduction

The issue of performance based building is not new in Denmark or internationally. Encouraged by the directors of the four Nordic building research institutes, the CIB Working Commission W60 was established in 1970. W60 defined the performance approach as follows [1]:

> *"The performance approach is, first and foremost, the practice of thinking and working in terms of ends rather than means. It is concerned with what a building or building product is required to do, and not with prescribing how it is to be constructed." (p. 4).*

In the following years, a number of articles on the performance concept was published. In 1974, the Danish Building Research Institute issued SBI Directions 94 on the why's and how's of the performance concept including the first performance-based specifications of requirements for non load-bearing internal walls and windows [2]. Under the leadership of E. J. Gibson, W60 published a number of reports on the performance concept and its terminology see e.g. [3, 4]. It was expected that prescriptive specifications would largely be replaced by performance-based specifications when the necessary fund of scientific knowledge was available. In reality, the picture has become rather blurry.

2. Setting the context

The Danish building and housing cluster is generally characterised by many small firms and a few large companies, but the industrial structure has been changing considerably in recent years [5]. Despite the current changes taking place, the building process is still dominated by the professionals, notably the architects and consulting engineers. Thus, the Danish building process has more in common with the British building process with its emphasis on consultants and cost-control than the French building process with its emphasis on contractors and cost-reduction. To echo Winch & Campagnac [6] and Winch [7], the Danish building and housing cluster can be characterised more as a professional system than as an industrialised system.

A number of policy studies have analysed the challenges facing the Danish building/housing cluster, see e.g. [8]. Most of these studies have been shaped more or less directly by the pioneering work of Michael E. Porter on the competitive advantage of nations and regions, see e.g. [9]. Although Porter's original diamond model of determinants of competitive advantage has been partly abandoned, the focus on clusters has prevailed. Instead, the Danish analyses of the building/housing cluster has turned towards more actor-oriented analyses focusing on the value chain. Figure 1 synthesises the framework deployed in a number of Danish studies of the building/housing cluster.

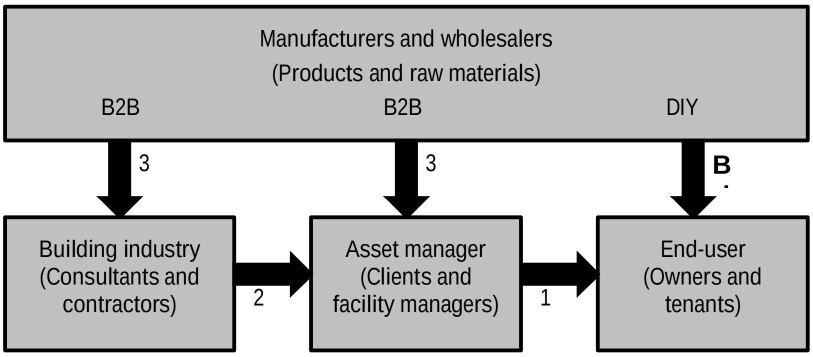

Figure 1: Markets and actors in the Danish building/housing cluster

The framework provides us with an overview of the *context* in which the actors of the building process have to operate. Framed by governmental regulation and the knowledge system, the building/housing cluster can be divided into four subcategories of actors linked through three separate markets. The four groups of actors are:

- The end-users consisting of e.g. owners of single-family houses, tenants, and employees.
- The asset managers of private, public and semi-public organisations running existing facilities and acting as clients of new buildings and refurbishment.
- The building industry consisting of planners, engineers, architects, contractors etc.
- The manufacturers including wholesalers of construction products and raw materials.

Each of the subcategories of actors is in principle linked through three separate markets of services and products. The three markets are:

- 1. A property market between end-users and asset managers.
- 2. A building market between asset managers and the building industry.
- 3. A product market between manufacturers and the building industry, asset managers and end-users.

On each of the three markets, different actors will procure and produce various products and services. A proper interpretation and translation of one set of performance requirements (e.g. from users to clients) to another set of requirements (e.g. from clients to the building industry) is crucial for creating best value.

3. The regulatory framework

The cornerstone in the Danish regulatory framework of building is a performance-based building legislation divided into three levels. The first level is a fully performance-based Building Act [10]. It should be noted that several other types of legislation are relevant when building in Denmark e.g. the Planning Act, the Act on the Preservation of Ancient Buildings, and the Working Environment Act. The Building Act covers new buildings, extensions to buildings, conversion of buildings and other alterations, any changes in the use of buildings that are significant, and demolition. The purpose of the Building Act is to:

- Ensure that a building is built and furnished in such a way that it provides sufficient security with respect to fire, safety and health.
- Ensure that buildings and surroundings are given a reasonable quality with respect to the intended use and proper maintenance.
- Promote actions to increase productivity.
- Promote actions to avoid unnecessary resource consumption in buildings.
- Promote actions to prevent unnecessary use of raw materials in buildings.

The Building Act defines when a building permit, a notification or no action is needed in order to commence and take a building into use. The Building Act describes the obligations of a client, delegates responsibilities to the local authority, describes sanctions in case of violations etc.

The second level of the regulatory framework is the Building Regulations, which are divided into BR-S 98 [11] for small buildings or dwellings and BR 95 [12] for all other types of buildings. In general, the Building Regulations are performance-based. Each chapter in the Building Regulations will begin by stating the targets to be met, for example [12]:

> *"4.1.(1) Buildings shall be designed and arranged so that, having regard to their use, satisfactory conditions are achieved for everyone with respect to safety, health, accessibility and use, and for cleaning and maintenance." (p. 41).*

In many cases, the commentary will point to various sources of information for recommendations of approved ways to comply with the building regulation. The commentary will for example refer to the SBi Directions, standards issued by Danish Standard or circulars and Orders from ministries and agencies, especially the Ministry of Labour.

In general, the Building Regulations do not stipulate solutions. However, you can find a few examples of provisions that directly stipulate specific solutions. One example is a provision that directly stipulates the use of lifts in multi-storey buildings. In the Building Regulations, you may also find a few examples of solutions not to be used. For example no pipes are allowed through the floor in the wet part of wet rooms due to poor performance of known practices.

The third level of the performance concept in Denmark is the SBi Directions issued by the Danish Building Research Institute. The SBi Directions describe various ways to comply with the Building Regulations. They are not mandatory, but usually clients, consultants, contractors etc. will follow the directions. The SBi Directions can be grouped in three main groupings:

- The first group of SBi Directions describes specifications and solutions that are recognised to comply with the requirements stipulated in the Building Regulations.
- The second group of SBi Directions describes methods and instruments for verifying if buildings satisfy the requirements stipulated in the Building Regulations.
- The third group of SBi Directions includes handbooks or guidelines to be used for planning and executing building works or investigating and assessing specific problems for example related to the indoor climate.

4. Procurement

Procurement can take place along different paths and include different forms of contractual and functional relations (for more details see e.g. [13]):

- Traditional/separate trades contracting.
- Main/general contracting.
- Design-build contracting.

Although practice differs, tendering will normally include five types of documents. The documents will be held together by a general document referring to all the relevant documents. The documents will be referred to in prioritised order in case documents are in conflict:

- General conditions describing the legal conditions for the work. Usually the general conditions will refer to the agreed documents described below.
- Special conditions describe various exemptions from the agreed documents, but may also hold certain special technical specifications.
- Technical descriptions and specifications of the end result and work to be done.
- Drawings.

- Appendices like time plans etc.

In Denmark, contracts and agreements are generally drafted according to general conditions described in ABR 89 for consulting services [14], AB 92 for provision of works and supplies [15], and ABT 93 for turnkey contracting [16]. ABR 89, AB 92 and ABT 93 are agreed documents acceded to by the government, local authorities, counties and all relevant parties of the building process. As opposed to private clients, public clients are obliged to follow the agreed documents and may only diverge from the agreed documents in extraordinary circumstances.

The agreed documents define the liabilities of consultants and contractors with respect to delays and defects. If the consultant is exceeding time limits without a justifiable claim for extension of the time limit, the contract can stipulate a penalty that the consultant shall pay to the client [14].

The liability of the consultant ceases 5 years after handing-over of the building or the works in which the error or the negligence occurs. Unless otherwise stated in the contract, the liability of the consultant is limited to DKK 2.5 million. The consultant is liable for damage when such damage is the result of not showing due skill and care. Thus, the consultant is not liable for damage arising from conditions which cannot be considered generally known in professional circles, for accidental damages or for errors committed by the client or by others engaged by the client. The exact interpretation of the provisions on liabilities is left to arbitration tribunals and the law courts [14].

The contractor's liability in case of delays are stated in AB 92 [15]:

> *"**§ 25.** Delays which do not entitle the contractor to an extension of time limits shall be considered the liability of the contractor.*
>
> *Subs. 2. Where provisions have been made for liquidated damages or other special penalties, no additional claims arising out of delays can be made in excess thereof.*
>
> *Subs. 3. Where no provisions have been made for liquidated damages or other special penalties, the loss suffered by the employer shall be assessed in accordance with the general provisions of Danish legislation on compensation." (p. 7).*

Cessation of the liability for defects takes place 5 years after the handing-over of building works and attendant engineering works. The contractor is liable for defects if the work has not been performed in accordance with the contract, with due professional care and skill or in accordance with any instructions given by the employer. The same shall apply whenever the contractor has failed to provide other services agreed on in relation to the work [15].

The provisions on turnkey contracts or design-build contracts set out in ABT 93 [16] largely follows the general conditions for the provision of works and supplies within building and engineering (AB 92), but differences do exist for example regarding securities.

5. Trends and challenges: Integrated teams

Looking at the building process in a longer time perspective may illuminate some of the changes that have occurred in the past decades and the challenges facing the procurement of buildings. The building process has undergone changes along four lines:

- Process: The conventional picture of the building process as a sequence of distinct phases (brief, design and construction) is being challenged. Increasingly, a value chain perspective is being followed thereby introducing new ways of organising building projects.
- Actors: New actors like facilities managers and users have entered the building process. Others have had their roles redefined for example contractors or manufacturers who often carry out part of the detailed design.
- Issues: A number of new issues like accessibility and sustainability have emerged or are emerging as new requirements.
- Products: Manufacturers have constantly introduced a long range of new products. Furthermore the Construction Products Directive is likely to stimulate a more open European internal market for building products.

Since the beginning of the 1990s, a number of development initiatives have aimed at improving productivity and quality in building through process development. The shortcomings of the conventional methods for procurement had highlighted the need for an integrated approach towards design and construction of buildings. In the past 10 years, a number of different partnering schemes have appeared along the conventional methods of procurement. Although the term partnering did not enter the vocabulary until the late 1990s, it was especially the public development programme Process and Product Development in Building (PPB) running in 1994-2002 that spurred on an increased focus on process development and functional integration of design and construction. The programme along with other experiments during the 1990s included a wide range of new production concepts and forms of co-operation like lean construction, partnering, value management and workshop design. Despite their differences in scope, the experiments shared an ambition of integrating the value chain across professional boundaries including closer and more substantial collaboration with the client.

These experiments and initiatives marked the start of a hybrid practice of design and build contracting. However, a number of architects and engineers e.g. from the PPB consortia complained that the vertical/horizontal integration is just design-build contracting in disguise and favours the large contractors. Thus, the Danish one-liner ”partnering eller partering” (translates into something like “partnering or cannibalism”) became a widespread slogan for the early discussions on integrated teams. Despite the obvious clashes of interest, the trade associations of consulting engineers, architects, small contractors, large contractors and clients managed to issue a common guideline on partnering in 2001 [17].

On January 1 2004, the guideline was followed by a new amendment making it mandatory for governmental building agencies to systematically assess if partnering is an appropriate way to procure a building project [18]. The amendment was followed by a guideline differentiating between two forms of partnering: “early partnering” or “late partnering” [19]. In early partnering, contractors will be involved before the client and his consultants have drafted a proposal. In late partnering, the client and his consultants have drafted a preliminary project. It is worth noting that in both cases the conventional methods of procurement are used, but contracts following the agreed documents on general conditions ABR 89, AB 92 and ABT 93 may need some adjustments. Thus, partnering is not a new procurement method but rather a new way of co-operating in a building project based on existing procurement methods.

6. An example from practice: Axel Heides Gård

As the Øresund Bridge between Copenhagen in Denmark and Malmö in Sweden was opened, an important precondition for an increased integration of the Øresund Region was put in place. On behalf of the Danish and Swedish governments two parallel and similar building projects in Copenhagen and Malmö were studied by a joint Danish/Swedish research team in order to identify differences and similarities of building in the two countries. Here only the Danish case Axel Heides Gård in the planning and design phases will be treated (for more details see [20]).

Axel Heides Gård has a unique location in Havnestaden in the heart of Copenhagen and with immediate proximity to both the harbour and the conservation area of Amager Fælled – a huge recreational area. Havnestaden used to be a heavy industrial facility, but the facility closed down and Havnestaden is now under complete restructuring and rebuilding as a new uptown area of mixed use for light services and dwellings.

The building project Axel Heides Gård was developed by Kuben, which is one of the largest and most experienced private developers in Denmark. Kuben employs around 160 people and its services include development of building projects, client services and facility management. The company has more than 30 years of experience of building homes for people. Kuben is a non-profit organisation owned by two non-profit foundations, but it is not a social housing association.

The ambitions of Kuben for Axel Heides Gård was to develop dwellings for young newly established families and senior citizens at an affordable rent. The dwellings are publicly supported tenants-owned dwellings meaning that there is a fixed maximum price for the dwellings. The project includes 84 dwellings with an average size of 98 m2 distributed on 16 different types of dwellings of varying size. Axel Heides Gård is a genuine and undemonstrative residential area. In this respect Axel Heides Gård is a clear representative of good Danish building practice.

After Kuben acquired the site, a team of consultants was assembled. Kuben employed a small architectural practice and a medium-sized consulting engineering company to develop a project proposal. Both companies including the specific employees involved had been working together with Kuben time and again. Thus, mutual trust had been built up over time and an informal partnership had been formed. Consequently, the consultants had developed a rather good sense of the usual requirements of the developer and good working relations with Kuben.

The contract with the consultants followed the agreed document on consulting services ABR 89 with two notable differences. First, the building project was going to be tendered as a design-build contract but the winning contractor was obliged to take over the consultants hired by Kuben without opportunity to change the contract with the consultants unless sanctioned by Kuben. This way Kuben could avoid the typical problem of design-build contracting where the consultants are squeezed and the project "massaged" by the contractor to cut costs but on the expense of the quality of the project. Thus, Kuben as client could maintain its right – and if necessary exercise that right – to decide in every detail the concrete solutions in order to ensure best value and at the same time include the experience of the contractor on buildability. Second, the contract sum was lower than usual as a consequence, because part of the typical services of the consulting engineer was to be delivered by the contractor.

During a three-months period, Kuben and the consultants developed the project proposal. As is common practice, the project proposal was rather detailed. Geotechnical surveys had been carried out, the overall design of the residential area was in place, floor plans were ready, facades including choice of materials and glazing were decided on etc. Since the proposal called for exemptions from the urban planning, negotiations with the municipality had to be undertaken and a hearing among the neighbours carried out. Eventually, Kuben could send in the so-called Scheme A – an application for public financial support for the project.

When the application was granted, Kuben started to market the dwellings. In order to start building this type of project, at least 75 % of the dwellings needs to be sold and a tenants-owners association has to be established. Due to the inherent lack of affordable accommodation in the metropolitan area, the dwellings were quickly sold out. When the tenants-owners association was established, the association took over the role as client and thus the risk of the project. Bringing the future tenants-owners into the building process also brings in new requirements to be dealt with. Since Danish customers are very demanding regarding their homes, a number of options for individual choices in the dwellings have to be available. Thus, in accordance with usual practice (at least outside the social housing sector) the design-build contractor offered a fixed and prescriptive catalogue of possible individual choices on kitchen interior, bathroom equipment, surfaces, floors etc.

Meanwhile, Kuben tendered the project and commenced the detailed design of the project together with the design-build contractor. In another six-months period, the detailed design was carried out in close collaboration between the developer, the consultants and the contractor. During this period, a number of detailed requirements were fixed regarding for example windows so that the contractor could order these windows from the manufacturer. Bringing in the expertise of the contractor on constructability, other more complicated issues like the exact design of the terraces of the penthouse dwellings being part of the roof of the building were resolved as well. In this problem-solving activity, more or less explicitly formulated performance requirements were debated against perceived problems and specific solutions in a continuous search-and-learn process.

As a paradigmatic example of the professional practice within Danish building, Axel Heides Gård illustrates two notable observations. First, although Danish building projects are procured within a largely performance-based legislation, there are strong elements of the prescriptive approach present in Danish building projects too. This is due to the wish of clients to exercise control of the end product, the administrative practices of municipalities, the dominant position of consultants in the Danish building process, and the elaborate involvement of the end-users.

Second, in many Danish building projects the consultant will set out relatively detailed descriptions of the end product, while the contractor will often be responsible for some of the detailed design, construction methods, choice of products etc. But even a largely performance-based design will have to be turned into a prescriptive design at some point in the project. If not before, then at least when the building worker has to decide what materials, colours etc. he is going to use to produce a kitchen, bathroom etc. Thus, the issue of prescriptive versus performance-based building is not an either-or issue, but rather a continuum stretching from performance-based to prescriptive building. Within this continuum, a negotiation space exists which can be exploited by the actors of the building process to be more or less performance-based. As the project proceeds more and more options will eventually be cut off by a prescriptive decision (see Figure 2).

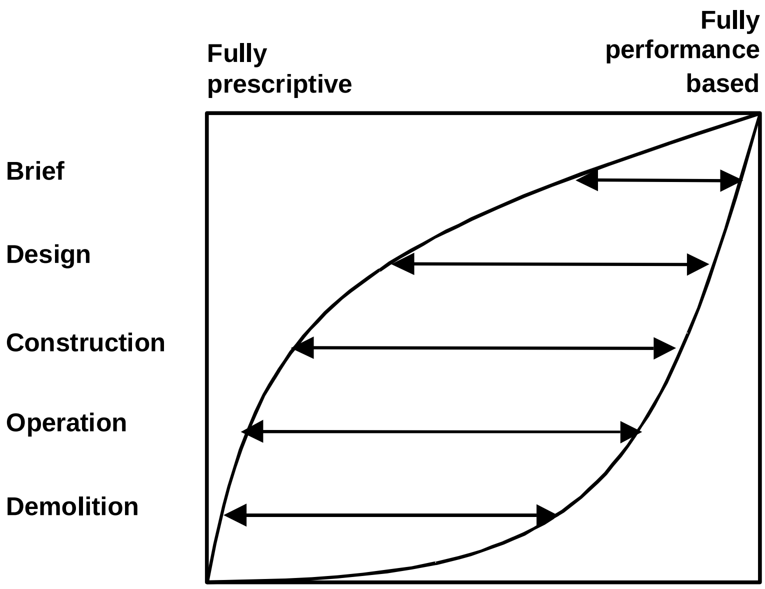

Figure 2: Negotiation space

7. Conclusion

First, this paper has scrutinised the Danish model for performance-based building. The cornerstone in the Danish regulatory framework of building is a largely performance-based building legislation divided into three levels:

- The Building Act.
- Building Regulations (BR 95) and Building Regulations for Small Dwellings (BR-S 98).
- SBi Directions describing various ways of complying with these regulation.

Although the Danish building legislation is largely performance-based, a few examples of direct prescriptions of solutions as well as examples of non-solutions can be found in the Building Regulations.

Second, this paper has identified a number of new trends and challenges to traditional procurement. A value chain perspective is challenging conventional pictures of the building process, the role of the actors is being redefined, new issues are emerging, and still more new products are being introduced. In the past 10 years, traditional procurement has come under pressure from especially partnering or integrated teams.

Third, this paper has examined the professional practice in Danish building. Although Danish building projects are procured within a largely performance-based legislation, strong elements of the prescriptive approach are present in Danish building projects too. This is due to the wish of clients to exercise control of the end product, the administrative practices of municipalities, the dominant position of consultants in the Danish building process, and the elaborate involvement of the end-users. Furthermore, the issue of prescriptive versus performance-based building is not an either-or issue, but rather a continuum stretching from performance-based to prescriptive building. Within this continuum, a negotiation space exists which can be exploited by the actors of the building process to be more or less performance-based. In conclusion: You can keep the performance-based door open for as long as you like, but you can't keep it open forever!

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Performance-based building from a Mediterranean perspective

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Abstract

One of the strongest points of PeBBu is having identified within the network four platforms for discussions which correspond to four similar geographic areas (North, South, Centre, East) to support the studies carried out in the framework of the project's scientific domains.

As regards the Mediterranean Platform (including Italy, Portugal, Spain, Greece, Israel and Slovenia) the two workshops held in Milan, Italy, in September 2003 and September 2004, highlighted some common regional factors that affect the concept of performance as perceived in this Region more than elsewhere as well as the barriers to the full implementation of this concept, which can also be found to different extents in other Countries.

Very briefly, some of the factors that most affect the performance concept, are:

- the influence of hot climate on materials and components behaviour and on design itself;
- living habits related to climate, as a factor affecting urban and architectural design;
- seismic risks;
- the need to establish a greater consistency between the most recent regulations based on the performance philosophy and more restrictive regulations concerning the protection and preservation of the cultural heritage.

As to barriers, in many South-European Countries the adoption of performance-based regulations is being seriously delayed and it is evident that the concept itself does not have the same meaning everywhere.

There also exist barriers of an economic nature and barriers linked to the specific culture of customers who are not able to clearly express their needs and, last, there is the problem of responsibility. In fact, whenever the designer is the sole responsible, it is evident that, whenever he can choose, the prescriptive approach proves to be safer than the performance-based one.

Keywords: construction, performance, materials, design, regulation

1. Overview

The Performance-Based Building (PeBBu) Network is funded through a Network subsidy within the Growth Programme that is part of the 5th Framework Research Programme of the Commission of the European Communities.

The main objective of the PeBBu Network is the “Stimulation and pro-active facilitation of international dissemination and implementation of Performance-Based Building in building and construction practice”, and in that context to maximisation of the contribution to this by the international R&D community.

The main components of this program infrastructure are, first of all, the international programming and coordination of research projects in nine scientific domains:

Domain 1: Building Materials and Components

Domain 2: Indoor Environment (former Building Physics)

Domain 3: Building Design

Domain 4: Built Environment

Domain 5: Organisation and Management

Domain 6: Legal and Procurement Matters

Domain 7: Building Regulations

Domain 8: Innovation

Domain 9: Information and Documentation

Late in 2003, the domains were brought down to six. In fact, it was decided to terminate three out of these nine domains (Domain 4, 5 and 9) due to various reasons such as an overlap of information in other domains, insufficient past or ongoing international research on the interface between domain themes and PBB.

- Involvement of target groups/stakeholders from the start of the programme through three User Platforms;
- Mapping of national and international research as far as related to – aspects of – Performance-Based Building;
- Four Regional Platforms in Europe to act as the bridge to and the initiator of aligned national activities;
- Network Management, including the establishment of a Network Steering Committee, a Technical Committee and a Network Secretariat.

2. Four Regional Platforms in Europe

In order to stimulate and facilitate national activities, to facilitate the input of typical national and regional characteristics into the international programming of projects and to prepare for the necessary future national implementation activities, four Regional PeBBu Platforms were established in the participating EU and EU Associate countries:

Region 1 (North Europe): Sweden, Finland and Denmark
Additional countries to attract: Norway, Iceland, Latvia, Lithuania and Estonia

Region 2 (West/Central Europe): UK, Ireland, Netherlands/Belgium, France, Germany
Additional countries to attract: Switzerland and Austria

Region 3 (East Europe): Hungary
Additional countries to attract: Poland, Czech Republic, Slovakia, Romania, Bulgaria and Slovenia

Region 4 (Mediterranean Europe): Spain, Portugal, Italy, Greece, Israel
Additional countries to attract: Cyprus and Croatia.

After applying to become a member in PeBBu Task 16, Slovenia has now definitely been relocated into the Mediterranean Platform. The reasons behind this relocation are the issues and topics dealt with in the Platform that are very close to the Slovenian reality.

At the end of the second year of the project, nearly all the objectives established in advance for the four Platforms were attained in the mid-term.

In particular, as regards the Mediterranean Platform, the most interesting results came out from the two Platform Workshop meetings, held in Milan in September 2003 and in September 2004.

The meetings focused on the discussion about the first State-of-the-art report as produced by the national partners of the Platform, centred around the topics dealt with by the nine scientific domains.

By comparing the different national scenarios, it is possible to outline common needs which are presented as specific recommendations in a Mediterranean perspective, in order to integrate the already accomplished scientific studies.

3. The Mediterranean Platform: the context of PBB

The state-of-the-art of performance-based building in the Mediterranean Platform, which includes Italy, Spain, Israel, Portugal and Greece outlines a very interesting and diversified scenario.

Historically, the performance-based approach originates everywhere at the beginning of the 70s, through different studies and researches and thanks the first voluntary standards. Over the following years, due to political and social issues, in some countries this process went through a setback, while in some other countries the performance concept has slowly but constantly got a footing.

In particular, starting from the great energy crisis which occurred in the late seventies, and over the next decade, nearly all Mediterranean countries provided themselves with laws dealing with energy-saving aspects.

In most cases, these laws were of a restrictive and prescriptive nature, due to the actual urgency of the situation and the culture of the time.

On the contrary, in Portugal, thanks to the favourable climatic conditions demanding for lower energy consumptions with respect to other countries, RCCTE (Regulations on the Characteristics of the Thermal Behaviour of Buildings) was at the same time focused on energy saving and thermal comfort of buildings.

Over the following years, environmental and sanitary emergencies and the strong cultural thrust of the CPD allowed to integrate the concept of mere energy saving with the specific needs of environmental sustainability and efficiency. Therefore, today the greatest efforts are concentrated on the revision of old legislations and the implementation of European Directives, among which Directive 2002/91/EC.

Over the time, in Spain many measures have been taken to optimise energy costs, to preserve the environment and to ensure the security and healthiness of living and working places.

The Plan for Public Housing (1998 – 2001) envisaged pilot schemes to promote sustainable homes where economical objectives met the need to preserve the environment. This policy was meant to develop suitable technologies in order to reduce the use of those materials whose production implied a risk to the environment, to reduce energy and water consumptions and to draw attention towards the specific bio-climatic conditions of the design site.

Also the development of photo-voltaic energy in the residential sector has been regulated with specific laws.

In Portugal, the E4 Programme contains a sub-programme for the building sector, the "National Energy Efficiency in Buildings Programme".

One of the activities within this programme consists in reviewing the "Regulation on the Characteristics of the Thermal Behaviour of Buildings"(RCCTE) of 1990 and the "Regulation on the Energy Systems for Air Conditioning of Buildings" (RSECE) of 1998. Other activities include the promotion of energy efficiency measures in public buildings and the promotion of the use of renewable energies in buildings.

Portugal is also considering introducing building energy certification.

In Israel, the amount of energy consumption in buildings is on the rise, due to a steady improvement in the standard of living and to the influx of immigrants in recent years.

To face this situation, the Ministries in charge are currently promoting a series of research projects with the aim of providing appropriate guidelines on the subject.

One of the topics that are being developed concerns the optimization of the use of sunlight in order to provide maximum comfort with a low energy consumption.

Another topic is about energy design tuned to particular hot-moist climatic conditions: the Israeli experience might be very useful to many other countries sharing the same conditions.

As far as Greece is concerned, the main framework of reference for energy-efficiency measures in buildings is the action plan called “Energy 2001”; a key action of this plan was the elaboration of a new national building energy code, aimed at replacing the existing thermal insulation regulation. According to other actions of "Energy 2001", including the reorganisation of energy management procedures in the public building sector, all public buildings needed to have an energy officer specifically appointed to deal with the energy management. This Plan has been supported by legislative initiatives, a draft Presidential Decree was prepared to establish financial incentives for energy-saving measures in buildings.

Ministerial Decision 21475/4707/98 was passed to improve energy efficiency in buildings in order to limit their contribution to CO_2 emissions. It introduced a variety of new measures in the building sector, including energy certification and energy audits of buildings, energy billing based on actual consumption, regular inspection of boilers, and third-party financing of energy conservation and renewable projects in public buildings. As of 2000, new public buildings – and as of 2004, all public buildings, including existing ones – are required to have an energy certificate, i.e. an energy identity card, stating the energy performance of the building based on an energy audit. Several measures have been introduced also outside the “Energy 2001” framework.

As far as energy-related topics are concerned, the Slovenian experience was quite different from the other countries.

First as part of former Yugoslavia, then as a country involved in the big conflict which broke out in the early nineties, Slovenia gained its “energy identity” in 1999 with the adoption of the new law known as “Energetski zakon”

Through appropriate measures, the Slovenian energy policy is giving priority to the use of renewable types of energy and energy resources that contribute to a lesser extent to environmental pollution.

The energy policy shall be focused on eliminating the consequences and replacing environmentally unfavourable technologies of using energy resources, whose combustion products accelerate the greenhouse effect (CO_2) and emit nitric oxide (NO) to the atmosphere.

This policy shall encourage the use of alternative resources at national level, and the use of smaller units at local level.

4. Main results from the Platform

The most interesting information emerged from the critical interpretation, from a Mediterranean perspective, of some of the results produced within the former nine scientific domains of PeBBu.

4.1 Materials and Components

The climatic difference between Mediterranean European countries and Northern European countries deserves to be further developed with a focus on the way it may possibly affect the behaviour and durability of materials and components.

Traditionally, laboratory tests are focused on the assessment of materials based on the influence of cold climates, while, for example, the effect of high temperatures on durability is not sufficiently investigated.

This aspect is particularly important also in the light of the climatic changes that are taking place at present that, according to meteorology experts, are accountable for the progressive tropicalization of large areas of the Mediterranean region.

4.2 Indoor Environment

Culturally and technologically advanced countries are nowadays paying a big attention to the healthiness of the indoor environment.

Over the last years the scientific production witnessed a great boost, first of all centred on the solution of the issues related to what the Americans called the “sick building”. Today, the culture of “biology” is directing studies towards the realization of a bio-building, that is to say, a building conceived and realized with technologies, materials and performances, that are not harmful to man and the environment over the time.

These last-generation studies are based on a performance approach.

The main difficulty today is represented by the overcoming of the prototype extent in order to turn the results of research into means and tools to be made available to designers and contractors.

Safety and healthiness requirements, such as fire-safety, acoustics, lighting, energy, hygro-thermal/moisture, should be reconsidered in the light of the specific aspects characterizing the Mediterranean area. Climate, traditions, culture are all factors affecting human habits and behaviour.

4.3 Building Design - Design of Buildings

There are at least two subjects that are quite relevant from a Mediterranean perspective.

First, the aspect related to safety during the construction phase. The building sector in Mediterranean countries is characterized by the presence of many small enterprises which are, in most cases, not well fitted out. There are in fact few barriers to penetrate this market segment, due to the extent and obsolescence of the building heritage that often calls for small maintenance and renovation interventions. To be more competitive, in many cases contractors make use of shadow and unskilled manpower and every year, for example in Italy, the price paid in terms of human lives is definitely too high.

In this connection, the recommendation is for the domain to include the Council Directive 92/57/EEC of 24 June 1992 on the implementation of minimum safety and health requirements at temporary or mobile constructions sites.

Another very important aspect is related to the seismic risk that, for the Mediterranean area is classified as extremely high. Israel is located in an area which is extremely subject to earthquake events and nearly all the Italian territory is characterized by such a phenomenon with different risk levels.

Another particularly interesting aspect regards accessibility. Since many years, in Italy attention has been increasingly drawn to frail users (the elderly and the disabled) to the point that the Italian legislation on the subject is deemed to be one of the most comprehensive and advanced today. The most recent provisions are also a good example of application of the performance philosophy to Italian laws.

4.4 Built Environment

A typically Mediterranean aspect is related to acoustic pollution. Southern Europe cities are traditionally more chaotic and noisy than Northern Europe ones. This is due to many factors (town-planning, density of population, traffic, etc.), among which the most relevant is climate. Where low temperatures force people inside, a more favourable climate encourages social relations and outdoor entertainment that imply a higher polluting load on the environment, especially from the acoustic point of view. In the light of these reflections, insulation products, systems and components, such as, for instance, façade elements, would deserve a differentiation by homogeneous climatic areas.

4.5 Organization and Management

The building process is, by its own nature, a melting pot of different competences and professionals. The main problem has always been the communication between all the actors involved in it.

No considerable differences exist, on this subject, among the Mediterranean countries according to their geographical position. This subject contains many pending issues that clearly nobody is still able to respond to in an effective way.

The Project Manager role has been more or less recently introduced in many countries and it represents a good opportunity to better manage the building process but it must be remarked that, at least in Italy, the training of such a professional role is still at dawn.

Two types of tools are proposed to assist owners, designers, contractors and supervisors, irrespective of regional boundaries :

- A list of requirements for each type of building, to identify the aspects to be taken into account;
- A software to support the management and to guarantee the performance of buildings.

4.6 Legal and Procurement

A contract with a performance value must describe what customers wish to obtain and then, at the end of the works, it must check whether the objectives have been achieved.

The domain report describes a universally valid model to support the achievement of final objectives.

The only objection to this point concerns the definition of satisfaction parameters that might vary from country to country and, in this connection, it would be interesting to identify the most suitable model to encompass the needs of Mediterranean countries.

4.7 Regulation

To complete the survey carried out among various European countries, it would be interesting to gather information about regulations in Mediterranean countries as well as in Turkey, Egypt, Cyprus, Malta and East-European Countries in general and to establish National Platforms to take into account national traditions, economies, climatic conditions and special factors which influence the Regulatory systems.

Thanks to the CPD, the first harmonized standards on products (the harmonised European Standards, and European Technical Approval Guidelines) are now spreading throughout Europe. These standards concern the performance of construction products. On the contrary, the European regulation still doesn’t guarantee the performance-based approach for what concerns the installation of products in the building, because the CPD does not cover all the performance aspects.

The performance-based approach remains limited to the regulation sector but still clashes with a scant culture outside the standardization sector; there should be a wide action to increase the awareness of users and stakeholders about the effectiveness of the performance-based approach.

The future review of the CPD may be an excellent occasion to draw more attention to the installation of products in the building (in other words, the recommendation is that the CPD should be more focused on the installation, which is already envisaged in the Directive).

A good question is whether the time is ripe to adopt a merely performance-based method in construction. Some projects are better carried out without a PBB approach.

As far as the Mediterranean Region is concerned, the PB-concept culture is slowly changing and it may be backed up by a good dissemination of results about cases proving the validity of such an approach.

4.8 Innovation

There is no great difference for what concerns the relation between innovation and construction industry in the different countries represented in the Performance-Based Building project.

Some aspects on this subject would deserve further investigations as to the performance concept applied to innovation.

A first remark concerns the fact that those who produce innovation can not take into account the performance of the building system or component where the innovative product is to be integrated. Safety aspects will therefore be tested by third bodies through the tools available today: the Agrément/Avis Technique, ETA (European Technical Approval). From this point of view, it is extremely important that within the domain, attention be drawn also to assessment systems, taking into account that the high costs involved are an obstacle to innovation for SMEs.

The importance of developing technologies that are more relevant to the construction process in Mediterranean countries should be more stressed for further elaboration within the Platform.

4.9 Information and Documentation

The scope of this domain was focused on the information infrastructure needed to support the adoption of performance-based building, with a particular care to the required development and introduction of user-friendly methods for gathering, making available and processing both general and project-specific information. To properly address this matter it is very important to know the information flow process, therefore a conceptual model of the flow was prepared.

5. Major barriers towards a more comprehensive adoption

The main barriers for strict adoption of solely performance-based regulations were precisely identified by the Israeli partners in the Platform.

The main barrier is the reluctance of designers and builders to accept responsibility for explicitly defined consequences. In general, many of them prefer regulations that define accepted solutions (Descriptive Approach), as compliance can easily be proven by the presentation of detailed drawings and construction brief. To prove compliance with performance-based regulations, calculations and/or laboratory certificates must be added, which usually imposes a larger workload on the engineers of the design team. In addition to that, checking compliance requires more skilled personnel. The shift from solely descriptive regulations to the adoption of mandatory Performance Requirements Standards thus encounters some difficulties at the design stage (mainly due to a lack of knowledge amongst professionals in some areas of building physics), as well as at the enforcement stage (mainly due to a lack of skilled personnel at local municipalities).

6. Conclusions

- There is a need to pay a greater attention to the specific issues of the Mediterranean areas, both at Community level and in terms of research and standardization;
- the seismic risk is very high in nearly all South-European countries and new provisions and rules are faced with a number of difficulties when they are to be enforced, even if they are inspired by a performance-based approach;
- a crucial aspect is represented by the climatic factor and the need to address such a topic in a more specific way, both at design and town-planning level, and for what concerns legislative and standardisation aspects, including laboratory testing;
- there is a need to define in a more precise way the concept of “performance-based approach” which still does not have the same meaning in all countries.

The Status of PBB in the NAS countries

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Abstract

This paper addresses the actual situation, background and the strategies of future implementation of PBB – Performance Based Building in the respective NAS (newly associated/associating states of Europe) countries: Bulgaria, Czech Republic, Hungary, Lithuania, Slovakia, Slovenia and Poland. The NAS countries are those belonging to the former Soviet block.

The objective of this paper is to describe why the situation of the NAS countries is so unique related to other platforms of the PeBBu thematic network. It will highlight the main barriers of PBB application in the NAS countries. This paper aims to enlighten, why the NAS countries show plenty of common features even if they are belonging to different regions, different language families, they have different historical backgrounds, different sizes and economical situations.

On the bases of the State of the art analysis, the paper describes the opportunities and potential strategies of spreading the PBB concept in the NAS countries. On this aspect, the accession to the European Union gives also a special situation and opportunities for these countries.

This paper is based on the NAS State-of-the-Art Report of the PeBBu network. The report was prepared by the task leaders and assisted by all members of the task and debated at the related PeBBu workshops.

Keywords: Performance based building (PBB; PeBBu); Newly associated states (NAS)

Introduction

The **scope** of the paper is to give an analysis of all aspects of future implementation and actual application of PBB – Performance Based Building in the respective NAS (newly associated states of Europe) countries on the bases of the PeBBu NAS State-of-the-Art Report. Task members are representatives from Bulgaria, Czech Republic, Hungary, Lithuania, Slovakia, Slovenia and Poland.

The **objective** of the paper is to present the background and the Status of PBB in the NAS countries with special focus on the ongoing PeBBu scientific domains and other PeBBu domain areas. Further **aim** is to provide a future vision and strategies for the implementation of PBB in the NAS countries in general and in the PeBBu domain areas.

At first this paper describes the background, why the situation of these countries is so unique related to other PeBBu platforms. It will describe the historical background of these countries that determined the possibilities of PBB and still influence the development of the construction sector.

The common features of the **construction sector** in the NAS countries will be pointed out. The paper will highlight the **main barriers of PBB** application in the NAS countries and on the bases of the background and the barriers it will discuss the **opportunities and potential strategies** of spreading the PBB concept in these countries. On this aspect, the **accession to the European Union** gives also a special situation and opportunities for these countries.

This paper will investigate the situation and the potential strategies of PBB in the NAS countries in the following ongoing **PeBBu scientific domain areas**:

Domain 1: Life performance of construction materials and components
Domain 2: Indoor environment
Domain 3: Design of buildings
Domain 6: Legal and procurement practices
Domain 7: Regulations
Domain 8: Innovation

The situation and the potential strategies will be analyzed also in the following **other domain areas**:

Built Environment
Organization & Management
Information and documentation
Fire safety & engineering
Accessibility
Facilities management
Energy & water management
Environmental sustainability
Education & training
Intelligent buildings
Structural design & engineering
Construction products directive (CPD)

As regards the **methodology**, the paper was prepared on the bases of the lessons learned from: PeBBu workshop; special PeBBu NAS workshops; PeBBu documents; contribution of the PeBBu NAS members; relevant literature and the scientific background of the task leaders.

1. Historical background, the construction sector and the status of PBB in the NAS countries

After the WW II all of the NAS countries were occupied by the Soviet army, and within some years became **soviet satellite states** with a very similar structure. An artificial socio-economical system was developed that determined the development of he construction sector and the possibilities of implementing the concept of PBB. There were special barriers of PBB due to this artificial system. In 1989/1990, the soviet systems collapsed, and new, democratic states were established. A **transition period** started from a planned economy to a market oriented economy in the 1990s with consequences and changes in every sphere of life. New barriers raised and the PBB thinking became even weaker than it was before the changes. In 1995 the NAS countries applied for EU membership and in the 1st of May 2004 ten of these European nations became **member states of the EU**. This situation gives new challenges and also new opportunities for these countries. These challenges and opportunities determine the development of the construction sector and the possibilities and strategies of further implementation of the PBB concept

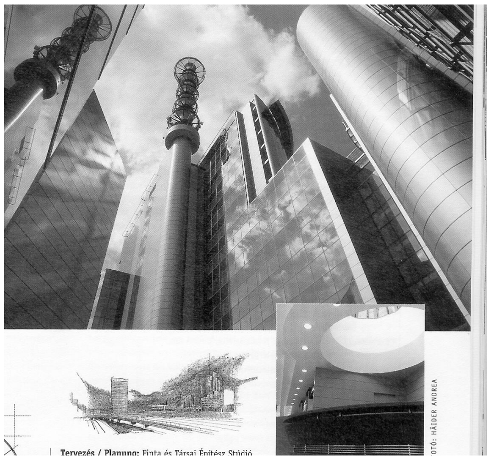
The **former socialist system** determined the development of the **construction sector** with the dominant role of the state and the practice of industrialization and mass production, that resulted a significant construction boom but with low quality buildings. Opportunities of getting proper building materials were very low, the lack was the most general feature and generally the performance criteria was adjusted to the only available solution. The low wages of architects and professionals and the ad hoc improvisation character and low quality of execution, all worked against the Performance Based approach. The standardization process was based on the opportunities of East-European cooperation, user requirements were not considered. The strong barriers of the artificial social, political and economical system before 1990 had a consequence of overall poorness comparing to the western countries.

The changes in the sector during the **transition period** occurred as a consequence of the former building practice. The strong role of the public sector stopped and the **privatisation** of the domestic building industry started. **International big companies** became new owners and realized large investments. These International companies basically make their research and development at the home countries, and rarely invest in research in the new countries. SMEs became dominant in the design and engineering practice. Ministries responsible for the building sector were ceased and the responsibility for the sector spread to several other ministries with the consequence of inefficient problem solving. With the **state withdrawal from the building market**, housing subsidies were dramatically cut, state investments became rare and low budgeted and inflation became dramatically high (over 30 %). As a consequence, **building industry has been declined**. The market type building demand became dominant and the investor began to be a dominant partner that often resulted in the lack of acceptable architectural quality. The segregation and fragmentation in building construction industry and the traditional approach to build as cheap as possible makes a rather great **increase in building failures**, basically in the residential sector, where the builders are mostly not professionals. Housing promotion is very low in all countries, the majority of the new dwellings are still built via a do it yourself practice or by black workmanship. **Black market** is very high in the building products field as well, partly due to the relatively high VAT. The transition period had also its difficulties as low skilled workers, low workmanship, low onsite safety, lack of quality inspection, instable financial background and high corruption rate. Also the problem of housing affordability emerged. On the other hand all up-to date products are available and also there are several prominent investments in the NAS countries.

Figure 1: Prominent investments in Budapest

a.) Siemens offices (architect: Lázár & Reimholcz)

b.) Police station (architect: Finta)



The special situation of the construction sector results also a **special status of PBB** in the NAS countries. Building activities in the NAS countries are the least performance-based among the PeBBu regions. Although CPD is entirely implemented in the NAS countries, the standardisation process is still rather weak and perspective in character. In the NAS countries in the construction practice the successful PBB usually depends explicitly on the responsibility and possibilities of all decisive partners and on their quality, but mainly on architect - client cooperation. The construction participants ordinary do not work in interdisciplinary teams and do not approach the construction in a wider context. The most important field, where the performance concept has been introduced is the technical approval of innovative products and related testing work. The most important fields, where further actions are needed are the design, procurement, budding and the control of the execution work in the platform’s countries.

Entering the EU in 2004 May, the **harmonization processes** in the NAS countries become more and more intensive. **CPD** determines the codes and decrees in all countries. The base would be the nominated Institutes of the countries for notification, which can act as a bridgehead of PBB. As a result of the NAS countries’ accession to the EU, it is expected that also the introduction of the performance concept will accelerate. There is a general agreement among professionals of its wider introduction.

2. Main barriers and opportunities of PBB in the NAS countries

A more general application of PBB would have several **advantages and opportunities** in the NAS countries, like the stimulation of new materials, techniques and competition, better performance of buildings, reduction of cost and risk and failures, more freedom and less barrier in design, more correlation with users' requirements, etc. However, **strong barriers** are still against PBB.

Barriers and opportunities of PBB can be classified according to different historic periods of their origin in the NAS countries, namely before the political changes, in the transition period and after the EU extension.

In the **time of socialism**, special barriers obstructed the implementation of PBB in the artificially isolated NAS countries, as the mass production, the COCOM list, the PLAN driven economy, etc. Most of these features are already over but some of them are still living or have influence.

As regards the implementation of PBB, after the political changes in the **transition period** new barriers and opportunities raised. There are still remnants of socialist mentality and short-term thinking. Lack of holistic approach, lack of cooperation, lack of finance, the weak credit systems and the low level of responsibility are all strong barriers. It is hard to achieve a breakthrough in habits joint to prescriptive regulations. There is a significant need for education and training and it takes a lot of time to become familiar with the performance-based approach. Other barriers are the lack of relevant indicators and testing methods, the lack of holistic life-cycle approach, the interest of producers, the segregation and fragmentation of design, engineering and construction or the attachment to traditionalism and routine. The conservatism of the construction sector doesn't promote innovation and change. Best Practice examples are not directly related to performance, and as investment in building is risky, lot of investors want to rely rather on proved and safe solutions. There is a low demand for the construction work in the domestic market. Smaller enterprises have no financial reserves and neither bank credits are available for them, which causes a high risk in surviving. The consequence is the decrease in the competitiveness in the construction market. Another special barrier is that older generation suffers from lacking speaking ability in foreign languages. English is very rarely spoken by the generation older than 40 years. That makes a strong barrier in implementing PBB materials, which are not in domestic language. On the other side the transition period resulted also in new opportunities, as the CPD implementation, the availability of new products and high quality buildings.

The **EU extension** can strongly influence many fields and so the construction sector in the NAS countries, most of them already member of the EU. N**ew opportunities and support of PBB** can be related to the free transfer of goods, services, information and people, more possibilities for innovations, more competitiveness, duty free prizes, more open society, European standardization, education and research support, decrease of regional and social differences, etc.

On the other hand, also some **new barriers** can emerge with the EU extension, like market deformations (temporary), the influence of strong interest groups, cartel agreements among producers, State budget deficit restriction, new tax policies, etc. **Obligations** are another aspect that comes with the EU extension and these should be considered rather as opportunities.

3. Status and strategies of PBB in the NAS countries in the ongoing PeBBu scientific areas and in other domain areas

The **6 ongoing PeBBu domains** are the followings: Life performance of construction materials and components; Indoor environment; Design of buildings; Legal and procurement practices; Regulations; Innovation. On the bases of the current situation this paper will draft some strategies that can serve the future implementation of PBB in the discussed domain areas.

In **Domain 1 "Life performance of construction materials and components"** we can see a development of quality and plenty of new up-to-date products, a product evaluation system and developing standards on one hand, however still plenty of low quality items on the market on the other hand. There are several researches related to durability issues, however few reference service life data are available and the factor method is not used in the NAS countries. Improving durability of constructions, developing new materials and techniques and increasing the use of local materials are priority aims. Well defined performance criteria, indicators, measurement and simulation tools are needed for further development. The works in ISO will impact and will direct the national efforts towards life performance of construction materials and components.

Issues related to **Domain 2 „Indoor Environment"** has not been really considered in the design process in the region, in spite of the increasing problems of indoor air quality due to more airtight buildings, open-burning heating equipments, moulds due to cold bridges, increasing level of indoor pollutants and emissions together with the lack of proper ventilation. Conditions for indoor environment in almost all countries are determined by legal and technical regulations but it is not controlled and buildings are typically designed for minimum permissible level. In practical design generally only aspects of comfort are considered, a more holistic approach to indoor climate and healthy building is seldom realized and this would be needed. Strategies should also address simulation, modelling and testing tools in order to predict complex indoor environment performances and also training special designers for indoor climate. A best practice example for careful indoor environment design on PBB bases in new construction is a commercial office building, the *"Tulipan House"* in Warsaw. Light, space, care for the natural environment, flexibility and comfort are the main features of the building. Special features will be sustainability and energy efficiency. The goal is to achieve 30% energy saving compared to a standard building and to use renewable energy sources to 50% of the total energy-use for indoor climate.

Figure 2: Best practice example for PBB: the "Tulipan House" in Warsaw, Poland

As regards **Domain 3 "Design of buildings"**, the former large state building design companies operated in the NAS countries have been divided into small design offices and the new situation caused new problems as well. Use of CAD systems became widespread, however the lack of control, the application of routine solutions, precipitation, the need of low construction cost are against performance-based design. In practice the successful PBD usually depends explicitly on the responsibility and possibilities of all decisive partners and their quality, but mainly on architect - client cooperation. Unfortunately, architects generally have a narrow orientation. Often "Ideal catalogue construction solutions" are applied and no explicit criteria and methodologies of the whole building performance monitoring and testing are used. Although several prominent buildings have been realized in the latest years, the former practice of do-it-yourselves still determine attitudes and austere buildings are constructed simply in possession of building permit without specification and implementation plans. A main barrier of PBD is that particular design participants do not consider the construction and its results as a complex system. Explicit performance criteria, less empirical approaches, a stronger control of technical and environmental performance, more complex tools & databases, whole life education & training are needed as a strategy. It is up to the architects and engineers to educate their clients in terms of PBB. It is important to increase the level of cooperation, communication and tenant/user participation in decision-making during the whole design and construction process on performance bases. Further aims are to develop and apply efficient Decision Support Systems, to improve the transparency of tendering and to apply Post-Occupancy Evaluations.

Figure 3: Examples of new construction activities in Bratislava, Slovakia a) Roman Catholic centre b) furniture department store Atrium c) housing complex in Kramare.

Concerning **Domain 6 "Legal and Procurement practices",** building affairs belong to the public administrational proceedings in the NAS countries. As former Ministries responsible for construction were ceased, responsibility for sector was distributed among 3-8 ministries. An inefficient operation was the consequence and especially housing policy became critical. The development of the institutional background, a construction policy and strategies are strongly needed. Regarding the procurement process, the building manager is responsible for it. The level of the application of performance criteria depends in particular cases on the building manager - his cooperation with architect, designer, contractor and his communication with the client. External influence will become important as a result of the implementation of new EU Directives and international obligations and this may require perhaps radical changes in the legislation documents. Consequently, it will be necessary to find a common framework for these provisions. In strategies it is important to develop construction process coordination and optimization, facility management and the tendering process. Also more information and databases are needed. It is important to work out efficient and more responsible construction and housing policies, to increase the quantity and quality of residential buildings and to develop complex programs for building renovation and urban renewal.

According to the main points in **Domain 7 "Regulations"**, the regulatory framework in NAS is composed of the Act on Construction and the Act on Construction products; National Technical Standards, European Standards (EN) and International Standards (ISO). Most of the EN and ISO are implemented in the region. The competent governmental institutions develop laws and decrees, while the Standards Institutions develop standards. The local authorities issue building permissions. Standards (mandatory / advisory) are related to special issues of the building regulations. CPD is the base document in all NAS countries and its implementation is almost completed. Although performance based concept has been integrated in the NAS Building Regulation in many areas, the national standardization process is still rather weak. Harmonization process with EU standards goes fast. The main strategies are to develop the institutional background of regulating the construction process and to develop performance based regulations and national standards on the bases of complex performance criteria and whole life cycle approach.

As regards **Domain 9 "Innovation",** after 1989 a

s large construction companies and central programs, also large research institutes were ceased and financial funds radically decreased. Mainly the Academic Research Workshops, Higher Educational Institutions, Innovation Parks, and Institutions for quality control exercise research activities today. Although there were several research programs related to PBB during decades, the application of innovation has several barriers as the common attitude of builders, the lack of R&D capacities of construction companies and the strong financial barriers. Great part of the innovative products comes out of the international research but there are excellent results also in the NAS countries. Several strategies could be defined, but first of all it is necessary to identify long-term values and make a balance between values and interests. Governments should promote innovation, education and training.

Further on this section a summary of the situation and the potential strategies in the following **other PeBBu domain areas** will be described: Built Environment; Organization & Management; Information and documentation; Fire safety & engineering; Accessibility; Facilities management; Energy & water management; Environmental sustainability; Education & training; Intelligent buildings; Structural design & engineering; Construction products directive (CPD).

As regards the domain of **built environment** more than 50% of the European population is living in cities, where two adverse processes can be observed. The symptom of sub-urbanization and deterioration of inner city areas are on one side and the increasing demand for good quality urban living is on the other side. The majority of the housing stock in the NAS countries cannot meet today’s needs, especially the run down and functionally obsolete inner-city blocks, the old mud houses and the large panel housing estates. Regulation of the development of the built environment and also regional planning has plenty of problems to solve. The process of sub-urbanization and urbanization should be balanced. New development plans are needed. There is a strong need for renewing, maintaining and operating existing buildings and for conducting complex urban renewal programs and large-scale panel reconstruction. Information channels should be also developed in order to inform all partners of the construction process and in authorities about problems and complex solutions concerning the built environment and its sustainability.

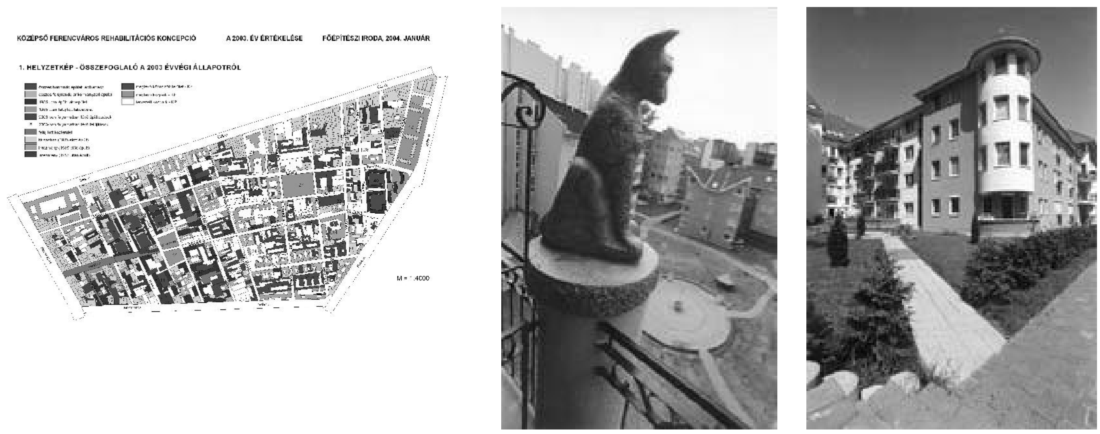


Figure 4: Best practice example of urban renewal program in Ferencváros, Budapest, Hungary.

Considering the issues of **organization and management**, the enterprises in the NAS countries have consistently began to build and should further develop the quality management systems and environmental management system, as next competitive advantage. There is lack of another certificate in safety systems that should be also created.

Documentation is related to the procurement process. In NAS the trends of traditional procurement model are dominant. Developing performance-oriented model is an issue of strategy and several barriers should be surmounted. As regards **information**, several professional journals and periodicals are issued and information materials available related to building and construction. Complex information on a performance bases should be created to stakeholders.

As regards the domain of **fire safety**, this issue gains a high recognition in the NAS countries. Testing laboratories are issuing certificates and approvals of materials and building elements from fire safety point of view. To develop fire regulations on performance bases and to provide more complex information on the subject would be necessary.

Regarding the domain of **accessibility**, the criteria are specified in the Building Regulations in most NAS countries, however only for public buildings are mandatory items to keep. More information and awareness and also proposals of accessibility in residential buildings are needed.

The group of the owners of the buildings applies **facilities management**. Since 1990 the tenure structure changed considerably in he NAS countries where the strong process of privatization has had serious consequences in maintenance and facilities management. Associations of the flat owners, special companies or housing corporations were established for facilities management. New acts are regulating their operation and organization, that should be further developed and the role of facilities management should be continuously increasing in the NAS countries.

As regards the domain of **energy and water management**, in the NAS countries the majority of houses are poorly insulated and strong energy conservation measures are needed. Reconstruction activities should be combined with additional thermal insulation. Also the practice of EU countries should be studied and the assessment tools developed. It is important to improve the energy-efficiency of buildings, to implement Energy Performance Directive, BEM and Building Energy Pass.

In the issue of **environmental sustainability**, all NAS countries are engaged for development, but in real term the national programs generally are rather week. Financial and political barriers are characteristic. To raise the public's awareness, to identify indicators for evaluation and to make proper practical measures for increasing environmental sustainability are strong challenges.

As regards ***education and training****, in the transition period the opportunities of the universities changed in the NAS countries. Neither education nor research got the necessary support. On the other hand international programs became open to NAS countries. PBB concept should be integrated in education, the general level of which is also necessary to improve.*

Concerning the domain **of intelligent buildings,** mainly the owners of new administrative and industrial buildings in the NAS countries apply the concept. As a realization of the user's expectations, intelligent buildings could be one of the platform to adapt the performance base approach. However, it is currently more a technologically oriented issue. It is needed to raise the awareness of the advantages of intelligent building systems regarding safety, security, indoor comfort and also to apply them in case of residential buildings.

As regards **structural design and engineering**, safety of construction is a performance based essential requirement in every NAS country. The performance of load bearing structures of buildings is addressed very strictly in the NAS countries. Internationally recognized researches should be continued in this field.

CPD was known from the time of its origin in the NAS countries and some principle like Essential Requirements came in law in the middle of the 90's. However, there is a lack of information of the control. CPD is an obligation and a good possibility in breakthrough in the NAS countries related to PBB. CPD should be also assessment based and clients' needs should have priority.

4. General strategies and the future of PBB in the NAS countries

The main **vision to the future** concerning the implementation of PBB is that after 10 years the differences between the NAS countries and the former EU countries will be decreased to a minimum level and most of the barriers will be ceased. Regional cooperation will be increased.

Several **strategies** are needed to realize this vision. Authorities should have an increasing role in developing construction policies, housing policies and strategies and in realizing these strategies. The institutional background of the construction sector should be developed in the NAS countries. The development of the national standardization processes is a key issue of strategy in implementing the PBB concept. It is important to raise the awareness of the professionals of the importance in thinking in performance terms. In order to spread the PBB concept in practice, clear performance criteria should be defined. In order to measure the performance in practice, indicators, measurement, testing and simulation tools should be developed. In order to increase the level and quality of regional and international cooperation, learning foreign languages should be promoted. These needs suppose the systematic institutional stimulation of research and the development of educational and construction activities at regional/national levels.

Concerning the envisaged **future implementation of PBB** in the NAS countries, in general only some participants of the construction design process are aware of PBB importance in practice. The construction companies formulate the need of PBB as the need of the complex quality of construction, which should be provided by the quality management. The barriers of wider PBB application in practice are seen in the cases when the particular construction participants do not consider the construction and its results as one complex system. The liability and responsibility is supposed to be a dominant factor enhancing the PBB. The increase of the education and knowledge level and the level of a systemic approach in the construction process are also fundamental conditions. The role and the quality of an architect is fundamental in the environment where the main criteria of a client's decision-making has economical character.

The necessity to **improve legislative framework** in the construction arise an excellent opportunity to implement the PBB approach. This opportunity could be very well detected in the widespread implementation and success of CPD in these countries. Experts believe that the increasing competition in the market will lead to a better understanding of performance based approach for the building industry.

5. Conclusion

In conclusion, relatively small number of best practice examples of PBB can be seen in the region and still plenty of barriers are against PBB. The complex solution how to support the PBB in NAS must issue from the promotion and propagation of cooperative approach of all partners to the construction based on complex building performance knowledge. The possibility of equal opportunities and the minimum threshold degree of economical freedom and stability are the fundamental conditions for this.

The accession to the European Union provides new opportunities, partly as obligations for implementing PBB in the NAS countries. Dissemination of the PBB concept and raising the awareness of it is important in all countries. National PeBBu Platforms would be important to develop in order to raise the awareness of PBB and overcome the barriers of languages in the participating countries.

If the key strategies will be conducted, the vision to the future related to PBB in eliminating the differences between the NAS countries and the former EU countries has good chances to be realized.

Performance Based Building and the Construction Products Directive

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Abstract

The aim of this activity in the Thematic Network (PeBBu) Performance Based Building is to provide basic information on the Construction Products Directive (89/106/EEC) to the PeBBu domains and members and to receive and incorporate feedback in a final report that aims at linking PeBBU with the CPD. In additions, although the CPD starts from the 6 essential requirements for works, it leads to product conformity attestation only. It does not provide the link between the performance based approach used in product specifications and a performance based approach for works. Together with the members of the PeBBu domains, this relationship has been examined.

1. Introduction

The objectives of the PeBBu Network are stimulation and pro-active facilitation of international dissemination and implementation of Performance Based Building in building and construction practice.

It has been acknowledged that the Construction Products Directive (CPD, 89/106/EEC) should be a basic element in PeBBu work and therefore, the introduction of the CPD is considered to be a horizontal task in PeBBu.

The Steering Committee of the PeBBu Thematic Network decided on 4th August 2003 to develop a new cross-cutting activity on the integration of the knowledge of the Construction Products Directive into the work of the various domains and tasks of PeBBu.

2. The Construction Products Directive

The Construction Products Directive (CPD - 89/106/CEE) defines six essential requirements for construction works, which are detailed in interpretative documents. Starting from those essential requirements for works, the European Commission, after consultation of the Member States of the European Economic Area (EEA), specifies the regulated characteristics for construction products and kits in mandates to the European Standardisation Committee (CEN) and the European Organisation for Technical Approval (EOTA) to develop harmonised technical product specifications, i.e. harmonised European standards or European Technical Approvals, for the performance assessment of the building products.

The EC New Approach directives in general and the CPD specifically introduce a mandatory system of conformity attestation throughout the construction products sector. For some parts of the industry, CE Marking is not really new, due to other existing EU Directives, but the CPD has important particularities compared with other New Approach Directives.

Thanks to the CPD, the way technical product specifications are being written has changed. It is expected that the CPD technical specifications will be a driving tool towards performance based works specifications and regulations in a very large part of Europe.

3. Objectives and accomplishments of this task within PeBBu

3.1 Objective I

The first objective of this activity is to provide basic information on the CPD to the PeBBu domains and tasks and to receive and incorporate feedback in a final report that aims at linking PeBBU with the CPD.

3.2 Accomplishments (objective I)

At the start of 2004, an extensive “CPD supporting document” has been made available to all PeBBu members, meeting the main part of objective I.

The document presents the legal framework, the new and global approach, within which the CPD has been established. However, the Construction Products Directive can be considered as a special Directive under the New Approach, because it diverts with regard to some of its fundamental aspects, such as

- the essential requirements, are not related to the products, but to the works into which they are to be incorporated;
- manufacturers are obliged to comply with harmonised technical specifications, i.e. harmonised European standards or European Technical Approvals;
- the conformity assessment modules, applicable for all other new approach Directives; the CPD has its own “attestation of conformity (AoC) systems”;
- putting into service is not considered in the CPD; only placing on the market is addressed;

- The CE Marking is accompanied by all the harmonised product performances;
- The Directive becomes applicable for products at the start of the co-existence period for the relevant harmonised product specification and becomes mandatory at the end of that period.

The CPD supporting document also presents detail to the Directive itself, explaining its scope and the essential requirements, which required “Interpretative Documents”. These were published by the European Commission, before CEN, the European Standardisation Committee, and EOTA, the European Organisation for Technical Approvals, could be requested to start developing the harmonised technical specifications.

The European Commission (EC) issues Guidance papers to support Member States, specification writers, Notified Bodies and manufacturers in performing their tasks under the CPD. These documents contain much of the EC’s interpretation of the CPD, which is under permanent development. This will be reflected in the CPD supporting document as it is being revised during the PeBBu project.

Since 2001, when the first harmonised standard was cited in the Official Journal of the European Union (OJEU), CEN has published close to 300 harmonised standards, about 150 of those having been cited in the OJEU, while EOTA issued 19 ETA-Guidelines and, more importantly, close to 200 European Technical Approvals. The CPD supporting document presents the CEN and EOTA organisations and procedures, which also develop over time.

One of the main changes that the CPD has brought to the Construction Sector is that all manufacturers will have to establish and maintain a factory production control system that meets the requirements described in the harmonised technical specifications. In some cases, independent third parties, Notified Bodies, will verify whether manufacturers (continue to) meet those requirements.

3.3 Objective II

Although the CPD starts from the 6 essential requirements for works, it leads to product conformity attestation only. It does not provide the link between the performance based approach used in product specifications and a performance based approach for works. Therefore, in Objective II, this project will examine how such a link is being or could be established.

3.4 Accomplishments (objective II)

Based on the extensive explanation about the Directive itself, the CPD supporting document also provides information on how the CPD has initiated or supported the development of tools to use the CPD deliverables beyond the legal framework.

Voluntary initiatives to increase users’ confidence in construction products, such as technical approvals and third party conformity assessment, which existed long before the CPD, have and continue to be developed and transformed to cover issues that are not covered by the CPD and because the CPD is performance based, these voluntary initiatives develop in the same direction.

Works' specifications will also benefit from recent activities of the European Commission, CEN and EOTA. The development of the Eurocodes as European Standards and the EC's recommendation on their use throughout the European Union is fundamental in the harmonisation of structural calculations and a link with harmonised product specifications ensures a future uniform approach. Similarly, though less publicized, activities are being prepared in the field of fire (fire safety engineering) and acoustics. For public procurement, the CEN and EOTA technical specifications are mandatory, if available, linking the CPD technical specifications to the works once more.

The **Energy Performance of Buildings Directive** leads to a new increased activity in CEN and EOTA in preparing performance based solutions to determine the energy performance of whole buildings, linking to the CPD deliverables.

The CPD supporting document has been presented to the PeBBu Members during the PeBBu Work Shops in January 2004 (Manchester) and November 2004 and was made available electronically.

4. Relation with PeBBu domains

4.1 General

An enquiry among the existing PeBBu domains took place, linking the CPD with the area of performance based building that the domains cover. This enquiry aimed at facilitating interaction with the PeBBu domains.

4.2 Domain 1 "Building materials and components"

The CPD foresees the development of technical specifications on a performance based approach and therefore, input from this domain was likely to be important. The domain concentrates on durability assessment and the parameters that influence durability. EC Guidance paper F covers durability under the CPD and the most important aspects have been presented in the CPD report.

The International Standards Organisation (ISO) has published some parts and is working on a whole set of the Buildings and Constructed Assets - Service Life Planning standards (subparts of ISO 15686) guiding the life design of buildings. The concept of the factor-based evaluation of the service life has been introduced in the International Standard for service life planning of buildings, ISO 15686 Part 1. The method allows an estimate of the service life to be made for a particular component or assembly in specific conditions.

It is obvious that the majority of the factors necessary to determine the service life are not envisaged in the framework of the CPD and that the CPD’s contribution is limited to providing supporting information regarding the products as they are being placed on the market.

The construction products can only be CE Marked when they are fit for use and influences of the (internal or external) environment on products are addressed in harmonised specifications, as well as maintenance. Design and workmanship are however not covered under the CPD.

Under the CPD, all products are assessed for general intended uses (e.g. fire protective coating or thermal insulation for buildings) and the durability assessment is not linked to specific intended end uses. The end result of the assessment is a manufacturer’s product specific durability claim when placing it on the market. Moreover, the CPD is particularly aimed at manufacturers, i.e. they take responsibility for CE Marking, but cannot intervene in design, use and maintenance of their products.

The usefulness of the service life planning methodology being widely accepted, but the practical implementation in product standards not consolidated, CEN examines how the concept can be introduced in European product standards, as a voluntary provision.

4.3 Domain 2 "Indoor environment"

When considering air quality, ventilation, thermal, sound and visual comfort, the CPD does not directly lead to ready-for-use deliverables. It provides product performances such as release of regulated substances, water vapour diffusion coefficient, thermal conductivity/resistance, airborne and impact sound insulation and sound absorption.

The CPD's third essential requirement "Hygiene, health and environment" will lead to technical product specifications that deliver the means for a performance based approach for the indoor environment and release to soil, surface and ground water, as far as these are influenced by the construction products.

Regulated dangerous substances requirements are not harmonised at present. National regulations continue to apply, but a new CEN Technical Committee will develop horizontal assessment standards for future generations of harmonised standards.

In the framework of the European Commission's Integrated Product Policy, another CEN Technical Committee will examine how existing draft international standards can be used as a basis for environmental product declarations over time. In the meantime, CEN Technical Committees developing product specifications are using an "environmental checklist" to introduce environmental provisions in their standards.

4.4 Domain 3 "Design of buildings"

In the framework of the CPD, the 6 essential requirements relate to the works, not the products. Therefore, although the CPD leads to product specifications, there is a direct relationship to the design of the works and many of the CPD deliverables, or related specifications, allow activities related to the overall design of the works.

Having produced product standards, some CEN Technical Committees are now developing installation standards. Since all CEN Member Bodies are obliged to publish CEN standards nationally, these new installation standards will lead to a de facto harmonisation of installation practices, since standards are the "state-of-the-art" and because these standards may be referred to from national legislation.

European Technical Approvals (ETA) always contain provisions regarding the installation of construction products and therefore, the link between the product specification and the works is very clear in these cases.

4.5 Domain 6 "Legal and procurement practices"

The existing European Procurement Directives, respectively addressing products, services and works, lay a direct link to the (mandatory) use of European standards and European Technical Approvals.

By contrast, the new, coordinated, Pubic Procurement Directive, specifies that technical specifications drawn up by public purchasers need to allow public procurement to be opened up to competition and therefore, it must be possible to submit tenders which reflect the diversity of technical solutions. Works' technical specifications should therefore be drawn up in terms of functional performance and requirements, and, where reference is made to European standards or European Technical Approvals, tenders based on equivalent arrangements must also be considered by contracting authorities. Tenderers are permitted to use any form of evidence to demonstrate equivalence.

4.6 Domain 7: "Regulations"

The CPD, due to its national implementation in all EEA Member States, sets a legal framework for placing construction products on the market.

Member States are required to take all necessary measures to ensure that construction products, covered by a harmonized technical specification, may be placed on the market only if they are fit for the intended use, i.e. that they comply with the harmonized standard or ETA, that the applicable conformity assessment procedures are being performed and that the products have been duly CE Marked. This implies an obligation for Member States to organize and carry out market surveillance, in a way that is effective and sufficiently extensive to discover non-compliant products.

The Council Resolution of 10 November 2003 requests the Commission to examine the possibilities of better cooperation between the Member States.

The enforcement of the Directive (market surveillance) has however received little attention so far. It is not certain whether Member States use a reactive or proactive enforcement regime, but most seem to opt for a reactive system.

CEN considers whether harmonised product standards are suitable for market surveillance purposes, i.e. do they permit Member State to verify compliance of products placed on the market.

4.7 Domain 8: "Innovation"

As far as innovation is concerned, at first sight, the CPD does not provide the means to encourage innovation. CEN standards usually cover products for which experience exists and even EOTA does not have all the answers for the integration of innovative products in the system, although the Common Understanding of Assessment Procedure (CUAP) was intended in particular for innovative products.

The manufacturers' desire to demonstrate that innovative products meet the requirements for CE Marking can be easily understood. If conformity with the essential requirements of the CPD cannot be determined in the early stage of development, it will be difficult to convince users to purchase the product, and illegal to sell it. Before CE Marking is possible, manufacturers have to perform ITT and need to have an operational FPC system for the product in place. Both might take a long time to perform and establish.

Without economical solutions for CE Marking of innovative solutions, innovation in the construction sector might decrease, which is obviously not the intention of the CPD. On the other hand, solutions may not compromise health and safety.

5. Recent developments

The Construction Products Directive has been around for more than 15 years and is producing its first results. Nevertheless, interpretation continues to be necessary, as stakeholders are faced with new practical challenges when CE Marking their products.

5.1 Different production methods

During the development of the recently adopted EC Guidance paper M on initial type testing (ITT) and factory production control (FPC), the European Commission acknowledged the different production methods in the construction sector and requested CEN and EOTA to adapt their technical specifications, allowing manufacturers, using any production method, to continue placing products on the market.

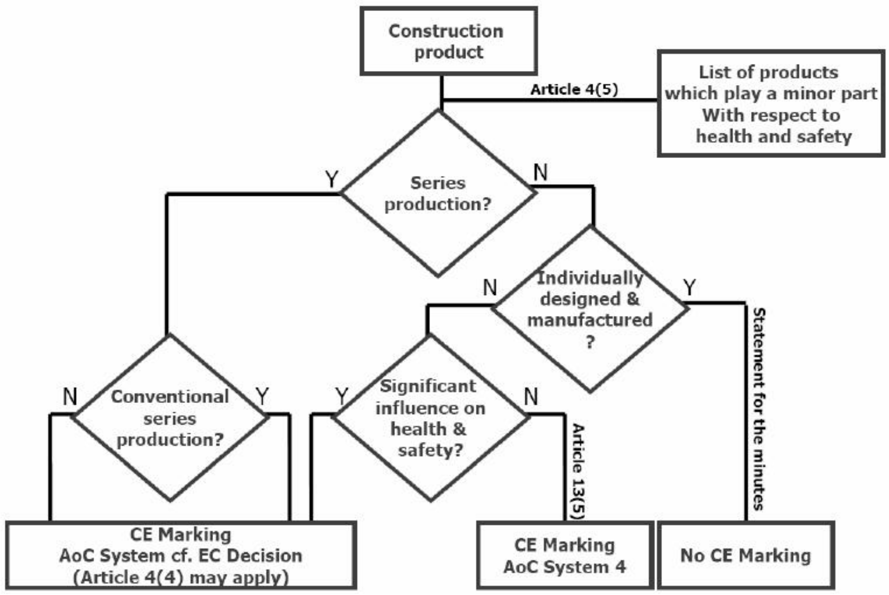

Figure 1: CPD Provisions regarding production methods

EC Guidance paper M distinguishes:

- Conventional series production: CE Marking obligation applies, conformity assessment in accordance with relevant EC Decisions
- Series production of products with varying properties (e.g. windows with an identical design, but different dimensions): CE Marking obligation applies, conformity assessment in accordance with relevant EC Decisions
- Individual (and non-series) production is divided into:
  - individually designed and manufactured products (e.g. restoration of cultural heritage); in this case, Statement N° 2 for entry in the minutes of the Council meeting that adopted the Directive in 1988 applies. Even if the product does not meet the (essential requirements of the) CPD, it can be placed on the EEA market, but without CE Marking, if Member States agree.
  - Individual (and non-series) production where the above does not apply, or in cases where the above does apply, but where Member States do not authorise the use thereof, the following options apply:
    - The products have no significant implications for health and safety: In this case, CPD article 13(5) is used, meaning that ITT and FPC are to be performed by the manufacturer, i.e. AoC system 4 applies, which may be contrary to the relevant EC Decision.
    - The products have significant implications for health and safety: In this case the EC Decision on AoC applies.

This differentiation, together with the European Commission's demand to CEN and EOTA to adopt proportionate conformity assessment requirements, should permit manufacturers of all sizes, using any of the above production methods to continue placing products on the market.

Although requirements need to be proportionate, they should also ensure that only safe products are placed on the market and requirements need to be equivalent, preventing market distortion, favouring one manufacturer over another. Performance based requirements, based on a statistical confidence levels are most likely important tools in this new development.

5.2 Placing on the market of products

Where there is a single manufacturer producing a construction product using an established standard manufacturing process from basic raw materials to placing the product on the market, then the responsibilities of the manufacturer and the Notified Body, if involved, are straight forward. However, in the construction sector, there are a significant number of situations where the supply chain includes other ‘actors’, e.g. sub-contractors of components and complete products, importers, distributors, merchants, where the responsibilities of the ‘actors’ and of the Notified Bodies are not clear and are not addressed in harmonised standards.

The CPD itself only considers the role of the manufacturer and his authorised representative. The ‘Blue Book’, which considers all New Approach Directives, and the EC Directive 2001/95/EC, the General Product Safety Directive, define the manufacturer's and distributor's roles.

In the framework of the New Approach, the **manufacturer** is:

- The manufacturer of the product, when he is established in the Community, and any other person presenting himself as the manufacturer by affixing to the product his name, trade mark or other distinctive mark, or the person who reconditions the product;
- The manufacturer's representative, when the manufacturer is not established in the Community or, if there is no representative established in the Community, the importer of the product;
- Other professionals in the supply chain, insofar as their activities may affect the safety properties of a product;

By contrast, a d**istributor is a**ny professional in the supply chain whose activity does not affect the safety properties of a product, while a s**upplier is a**n entity that supplies materials or products without placing them on the market, i.e. an entity that supplies goods to the manufacturer, responsible for designing and manufacturing a product with a view to placing it on the EU market

An a**uthorised representative is a**n EU established entity, appointed by the manufacturer to act on his behalf and recognised as such. The manufacturer remains responsible for the actions of the authorized representative under the CPD.

An **importer** *(who places a product on the market) is a* distributor who takes a product from a third country and places it on the EU market.

These definitions clarify the responsibilities as far as CE marking construction products is concerned.

Distributing a CE marked product, but not affecting the essential characteristics. A distributor buys in a packaged product, e.g. on a pallet, in a box, etc, and sells it to others without affecting its essential characteristics. The CE Marking is that of the manufacturer. The distributor is responsible for taking care that the packaging is not damaged and that the storage conditions defined by the manufacturer are respected (temperature, humidity, ...), i.e. the responsibility of the 'distributor' is limited to maintaining the integrity of the product and producing associated documentation as necessary for local use.

Repackaging and CE marking without affecting the essential characteristics. When a CE Marked product is repackaged, without its essential characteristics being modified (e.g. by transferring from a vat of 200 litres to 1 litre bottles, or by affixing a new label with his own brand name to the product and not referencing the original manufacturer who CE-marked the product), the entity responsible for repackaging is a manufacturer under the CPD. If the manufacturer does not want to refer to the original CE Marking, he has to apply a new CE Marking to his products making use of the original manufacturer's declared values, and to use a Notified Body, if required. In this case, the key element for CE marking is traceability. The Notified Body should consider that the product complies with the CPD, based on the original manufacturer's CE Marking, and check primarily that the repackaging manufacturer has taken all necessary measures and procedures to ensure that the properties of the product were not altered by repackaging. The repackaging manufacturer must always be able to prove the product he repackaged was CE Marked by the original manufacturer by showing a correspondence between the branded product he places on the EU market with his CE Marking and the CE Marked batches from the original manufacturer. The traceability has to be fully guaranteed.

Changing the properties of a CE marked product. If a manufacturer buys in a product and changes its properties before selling the product, he becomes a manufacturer under the CPD and must CE Mark the product as he places the product on the market.

5.3 CPD Performance based specifications

Chapter II, Article 7(2) of the CPD says "The resulting standards shall be expressed as far as practicable in product performance terms, having regard to the interpretative documents". Consequently, all EC Mandates to CEN and EOTA foresee that provisions in technical specifications should be expressed, as far as practicable, in product performance terms.

However, manufacturers being confronted with the legal requirement of CE marking all construction products find that testing may be expensive and CEN and EOTA are continuously being requested to simplify requirements. In addition, the technical state-of-the-art may not (yet) permit replacing existing design knowledge by test methods (e.g. durability requirements), preventing CEN and EOTA to introduce performance based requirements. Calculation, which may replace expensive testing, may also be burdensome and/or expensive.

Therefore, the European Commission concluded alternative solutions are necessary to remove some of the burden on manufacturers. The first solution used was the publication of deemed-to-satisfy provisions in the case of reaction to fire class A1 products in an EC Decision, permitting manufacturers to claim class A1, without testing. This principle is now also being used for other reaction to fire classes, through classified without the need for further testing (CWFT) in the case of (other) reaction to fire classes. These CWFT cases are also published in EC Decisions.

The solutions above are published in EC Decisions, since reaction to fire classes are regulatory classes. For non-regulatory classes, CEN and EOTA can introduce technical solutions in specifications, preventing testing and/or calculation through conventionally accepted performances (e.g. tabulated values, « typical » solutions).

However, specifications should always permit manufacturers to claim superior performances than those specified in deemed-to-satisfy provisions, CWFT-cases and conventionally accepted performances through testing (or calculation), encouraging innovation and preventing new barriers to trade.

Therefore, recent CPD technical specifications incorporate the principles of the performance approach by specifying:

- Requirements (objectives to be achieved)
- Verification methods, i.e. testing or calculation, which can be used to demonstrate whether or not products meet the requirements
- Performance expression methods (threshold performances, characteristic value, classes, levels, …)

And in addition, they specify products, materials, design and construction methods considered to meet threshold performances, levels or classes, without the need for testing.

Most CPD technical specifications will include both prescriptive and performance elements, but should in all cases be primarily performance based. The EC seems to adopt the idea that the performance approach is a means to develop technical specifications, promoting innovation and preventing barriers to trade, but not an end in itself.

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Section IV

Performance Based Building Experiences outside the PeBBu Network

Energetic-environmental certification of the urban lighting installations

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Abstract

Today the urban lighting at last performs a significant role in the field of the issues concerning the regeneration, the organisation and the urban promotion. During the years the progressive awareness about the necessity to determine a specific luminous night landscape has led to a definition of new objectives of intervention. In past times, the role of the urban lighting had a merely functional nature; just afterwards it acquired a figurative value, connected to the rereading and promotion of the urban landscape during night-time. However, in both cases the planning process was basically connected to the definition of a prevalent level of priority, responsible for the clear separation – visible for years – between the functional lighting and the architectural one. The will to define a night landscape for the urban environment entailed an increase of the level of complexity of the lighting processes, due to the increase in variables involved. In fact, the result – product of a holistic vision – is obtained only through the synergetic action of different levels of objectives. The urban lighting changes into a control of the relationship between the plant and the urban environment during the whole life-cycle, so considered in the totality of its functions:

- as an instrument of fruition and upgrading of the built environment. Function of the different destinations of use, of the specific spatial typologies, of the urban structure and morphology;
- as a service of public utility. Function of the efficiency, efficacy, economic character of construction and of consumption, of the easiness of maintenance and management;
- as an instrument for the sustainable development. Function of the reduction of the environmental loads and of the applicability of specific eco-compatible solutions.

The insertion of this latter function within the levels of objectives of an installation of urban lighting is definitely one of the most innovative aspects within the process of planning. The most suitable technical normative instrument to use is the need-performance based approach which emerges as an open system which can also be updated. Acting on the specifications of performance within the energetic field, the technological-innovative field, the field of quality of urban environment and of environmental and economic impact, it is possible to define procedures

for the achievement of different levels of quality within the intervention of urban lighting. The final goal is to classify the whole light installation according to its own performance and ascribing to the installation a score equal to the level reached by the same performance. This objective is operatively reached trough a separation into homogeneous parts of the problem organised in working phases. The operating model is developed through the phases of: analysis, definition of the objectives, individuation of the solutions, verification and assessment of the performance level. The conformity of the work performance to the requirements which have managed the planning, the construction and the management of it, sets its level of quality. This means to assert that the process of analysis-verification-assessment makes use of the comparison with benchmarks, properly located (identified), through which it will be possible to give an assessment of the light installation for areas of evaluation. The concept of ‘area of evaluation’ turns out to be a methodological instrument able to consider the different levels of requirement and the connected levels of objective (coming from the assignation of a weight, in terms of importance, to the hierarchy given to the different requirements to satisfy). In this perspective it is also possible to insert the lighting in the process for the sustainable urban development, as a component for the reaching of the parameters established by Kyoto’s protocol. This methodology involves in its own realisation all the actors of the process: from the utilities to the contractors, from the local authorities to the designers bound by a unique synergetic aim for the reaching of specific energetic and environmental performance.

Keywords: score rating system, need-performance based approach, requirement classes, levels of performance, areas of evaluation.

1. The process of environmental urban – lighting system

The urban renewal and the sustainable development of the landscape are themes of great interest, at the centre of the present debate about the reassessment of the town and of the urban policy. In particular, the urban renewal – apart from considering all the aspects connected to the identification of the values to preserve in historical-architectonic and landscape terms – can’t leave out of consideration the identification of strategies suited to the energetic-environmental management, able to improve the use of the areas, without causing disturbance to the present ecosystems. In this specific case, the reduction of the field of investigation to the system of empties constituting the connective of the urban fabric, and the restriction of the field of investigation to the process of urban lighting, define the environmental urban – lighting system. It is aimed to the satisfaction of the following requirements: improvement of the life quality, upgrading of the urban image, efficiency and energy conservation, sustainable development. It’s obvious that these requirements put the process of urban lighting in the field of the issues concerning the urban renewal, organisation and promotion, because it is able to produce economic, social, cultural and tourist implications. Moreover, the delineation of a complexity of contents, like this, implies the involvement of intervention politics characterised by more and more complex solutions, able to have important repercussions on the night landscape, on the activities carried out in it and, at the same time, on the sustainable development (through solutions of control of energy consummations and use, coming from renewable resources). Anyway, the promotion of the improvement of the quality of urban lighting has to consider the local conditions and the fact that the system consumption, management and maintenance is today a considerable charge for the local government; moreover, it has to consider the opportunities caused from the definition of an identity of the luminous night landscape in the process of renewal of the urban image. The progressive awareness of the role of the urban night landscapes has brought during the years to the definition of new aims of intervention. So, the aim to preserve and upgrade the identity of the places merges with the transformation processes; these latter are generated by the changed social requirements and by the need of development centred in the perspective of efficiency, efficacy, sustainability and low costs. The aim to pursue the improvement of the quality of the urban landscape – lighting system implies the setting-up of multidisciplinary and specialist tools to manage the complexity for the identification of qualitative, quantitative and procedural solutions. Practically it performs through a whole of actions – promoted by the local government – able to start a path of careful revision of the normative tools of guide and control of the whole process. As a consequence, the local government becomes the main actor of the possible transformation of the process of urban lighting and of the promotion of a new development model which respects the historical-architectonic heritage, the environmental values, the social requirements and the technical-economic practicability.

2. Aims

The task to guarantee specific qualitative levels of the luminous installations becomes the main purpose in the improvement process of the quality of the urban environment – lighting system. The qualitative levels are measurable in terms of performance (night and day urban environment performance, energetic-environmental performance, technological performance, economic performance and procedural performance). So this approach implies the definition and the classification of different reading levels about different and correlated disciplinary fields. The achievement of the result – product of a holistic perspective – can be reached through the synergetic action of several levels of combinable aims, organised and pursued through rules which define a technical normative of performance inside the process. This normative is aimed to the achievement of performance levels of intervention corresponding to the satisfaction of the purposes coming from the analysis of a basic requirement framework. The achievement of the aims requires:

- a strategy of intervention;
- a practical methodology.

3. The strategy

In this field, the satisfaction of the requirements revealed can be articulated through two different levels of action:

- the definition and the examination of a complex framework of requirements, which takes shape as an open system that can be updated. It is structured through the need performance based approach thanks to: the levels of aims, the classes of requisites, the compulsory and voluntary requirements and the performance specifications (indicators) for the achievement of the expected qualitative levels;
- the indication of procedures for the co-ordination of the activities which make up the phases in which the process is disassembled.

So, the promotion of a new development model of urban lighting implies the definition of an intervention tool which, acting on the performance specifications in a technological, energetic, economic field and in a quality range of urban environment, can define some procedures through which it can take into consideration the different levels of performance. They are practicable in the strategies of project, construction, management and the divestment system, or during the various phases of the process.

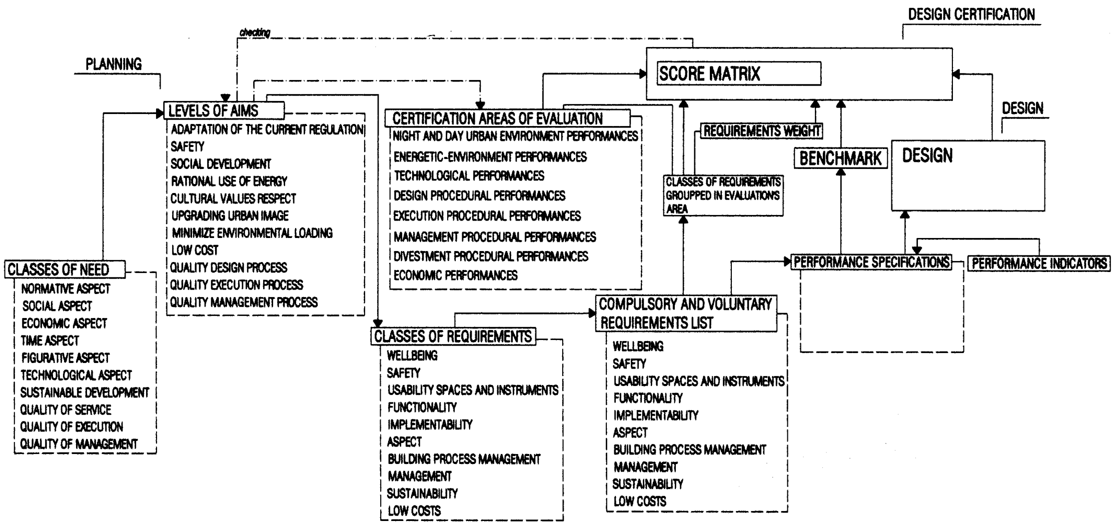

Figure 1: Need-performance based approach flow

4. The methodological approach

The innovation of the approach consists in the definition of a development model of the urban lighting process based on the fulfilment of a framework of requirements a priori defined. The translation of the requirement classes to satisfy in levels of objectives to pursue (health, security, satisfaction of social expectations, environment safeguard, rational use of energy, upgrading of the day and night urban environment, adaptation to the current regulations, etc.) is the methodological assumption of the process and enables the development of a *management system for the quality of urban lighting.*

This system is a way to conceive and represent a non-repetitive process, which can be greatly differentiated for aims and environmental context. Practically it is applicable through a division structured in components organised in levels and through supporting procedures to the macro-phases: productive out work, decision-making and productive in work.

It's organised by means of an inner technical normative instrument which has the task to guide and check the process (as a support of rational behaviour). It is capable to order in hierarchy the goals of each phase making up the process (planning, designing, execution, management and divestment). It is also able to connect them finding the relationships between the fact-finding areas in which the system is divided (usable spaces system, technological system, figurative system and procedural system). The development of a management system for quality provides for the definition of a practical methodology based on the structured division of the process in systemic connected components and on the classification of different sectors in which they can be articulated. This tool, using the individuation of goals and acting on the performance specifications, rather than on established solutions, is adaptable to each local reality. So, it is possible to do a first division in:

- urban lighting product-service system;
- urban lighting process system.

The system concerning the urban lighting product-service is a tool able to define and check the minimum levels of acceptability. These is the minimum requirements acceptable, which the system in its globally has to satisfy. The content of the system regarding the urban lighting product-service is functional to the need to structure the urban-lighting environment system in the following parts:

- spatial and environmental condition system;
- technological system.

It's useful to classify the following subsystems:

USABLE SPACES SYSTEM

- functional-dimensional system: concerning the use destination, it deals with the geometrical, dimensional, distributive, space-relationship aspects to the different levels of complexity, with specific reference to the requirements of wellbeing, usability, safety, integrability, aspect and management; its object is the spatial category, the settling complex.
- physical-environmental system: concerning the artificial microclimate, it deals with the aspects defining the environmental conditions of the spaces, with specific reference to the requirements of wellbeing, usability, safety and sustainability; its object is the environmental unity, the spatial category, the setting complex.

TECHNOLOGICAL SYSTEM ascribed to the requirements of the usable technology, it defines and checks the behaviour of the technological parts that make up the spaces in connection with the above-mentioned requirements; its object is the technological unity, the technical elements, the equipment and the material.

The system concerning the urban lighting process is developed during the temporal phases of the planning, realisation, management, maintenance and divestment. It requires the realisation of operational models and suitable actions to check the development of a management system for quality. So, it becomes the tool to use and to structure the procedures to manage and check the phases of the process. It’s made of a range of phases (sub-processes) interacting in parallel or in sequence, in which the management system for quality becomes a strategic factor to identify the aims to pursue, to programme the activities, to plan the test and the controls to carry out.

PROCEDURAL SYSTEM regarding the activities which characterise the process. It concerns the programmatic, organisational and managerial aspects connected to the execution of this activity. It also concurs the roles of the operators involved in the process.

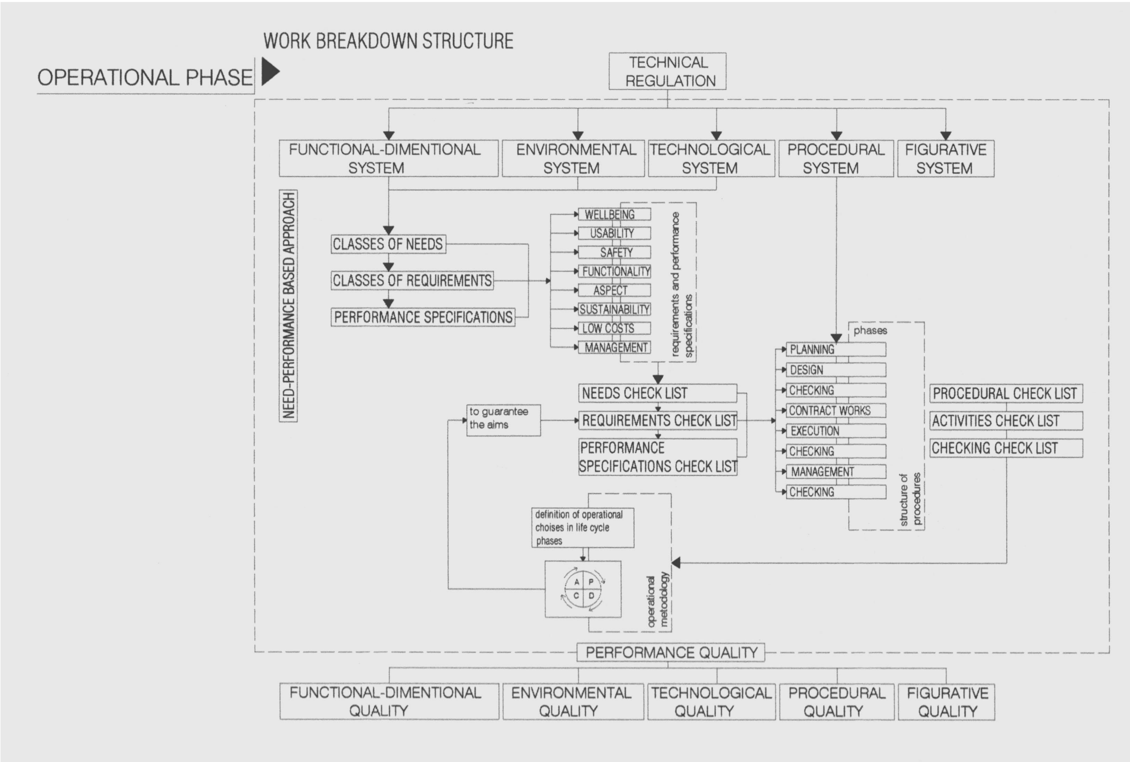

Figure 2: W ork breakdown structure of operational phase

This merely methodological approach is used to reread and systematise the characters which structure the luminous process of the historic centre. In other terms, it is necessary to apply different levels of reading of the disciplinary fields, interacting in a system of connections between the urban landscape and the technological system. The classification of the relationship spaces in spatial typologies and categories, with the following definition of the characteristics to upgrade or to ignore (through a value judgement), will intervene as a basic fact-finding structure. Then, it will be a support – as above-mentioned – of the procedural structure for the development of the temporal phases of the process: planning, design, execution, management and maintenance, divestment, in addition to the checking phase. This latter acts at the end of each previous phase. A division of the process according the need performance based approach and the following reassembling of the parts, assure the chance to define a guide-check tool of the urban luminous process able to allow, at the same time, a plurality of solutions.

5. Operational tools

The operational methodology based on a framework of requirements and on a procedural system uses a series of supporting tools through which the management system for the quality of the urban lighting process is practically accepted. In the following scheme it is possible to pick out:

- the urban lighting masterplan, guide and planning tool for the interventions, is calibrated for the middle-long term and identifies all the interventions to realise. Even if it doesn't have its own economic resources it has the task to define guide lines to choose the technologies and the techniques to use.
- The urban lighting programme, calibrated for the short-term, only includes those actions on which the agreement between the public and private parts took shape. It has the financial resources to carry out these actions.
- The energetic-environmental certification of the phases of the urban lighting process, instrument used to check and measure the reached performance levels.

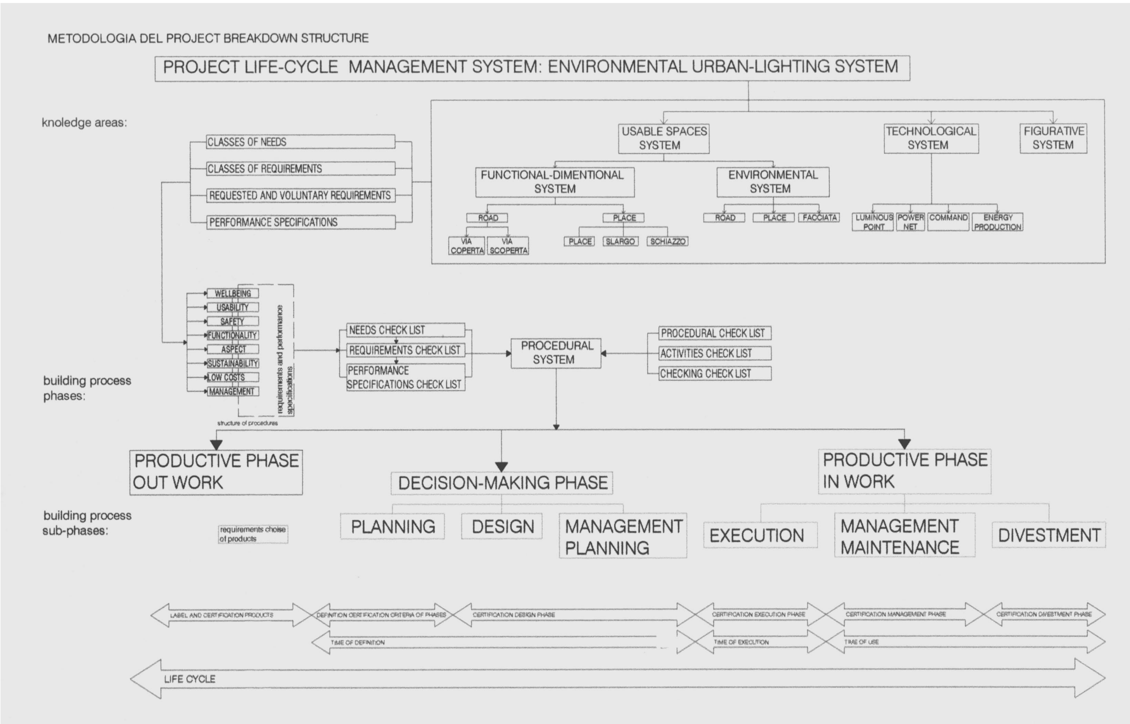

Figure 3: Work breakdown structure of operational phase methodology

The need to define an urban lighting masterplan comes from the will to give an organic development to the interventions of the municipal area. It intervenes as a planning tool and it has as purpose the definition of: the criteria of intervention for a luminous night landscape, the priorities of intervention and the technological, energetic-environmental and technical-administrative principles. It allows to define an operational methodology and supporting tools (abacus of conformed solutions and solution models) aimed to the pursuit of specific qualitative levels. Consequently, it is an instrument which can define the contents of the energetic-environmental certification process of each intervention (requirements of the evaluation's areas and assignation of weights in the score matrix, indicators and criteria of score assignation, chart of synergetic awards, assignation chart of certification levels, correspondence of awards).

The other two instruments intervene during the following phases of the process and require a deep revision of the relationships between public and private subjects. In fact, they are suitable to operate in the complexity delineated in the energetic sector, in which the urban lighting systems take their place. Exactly, the foreseen model goes toward a negotiated planning of the development of the urban lighting. It is necessary to pursue the realisation of objectives of economic development, connected to actions of social, environmental, formal and technological upgrading. The liberalisation of energetic markets, the acknowledgement of the European directives about the energy conservation and about the development of the renewable sources, the resolutions of the AEEG, the white certificates or titles of energetic efficiency, the role taken from the different actors involved (distributing societies, selling societies, ESCO, etc.), all that require a complex structure of procedures. Therefore, the programmes – projects require the definition of concrete interventions to follow, coming from the different technical-economic alternatives. In this perspective the quality component becomes a strategic factor for a correct management of the processes of urban upgrading and of sustainable development of the area. Moreover, the instrument energetic-environmental certification answers to the principles which structure the conception of a new model of development and upgrading of urban lighting:

- the objectives satisfaction principle
- the compensation principle

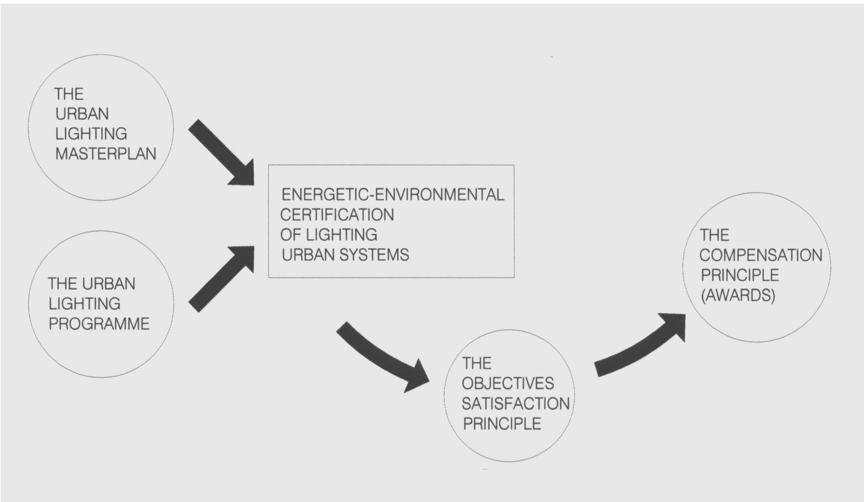

Figure 4: The principles

6. The principles

6.1 The objectives satisfaction principle

The development of the management system for quality is aimed to guarantee the fulfilment of the foreseen objectives. In this field the check phase has a determinant role. In fact, the use of :

- the need performance based approach: with the definition of the requirements to satisfy to reach the performance levels;
- the processes approach: with the definition of the procedures and of the check lists,

implies the necessity to have an evaluation system of the requirements fulfilment degree and of the efficacy of the system. This can be obtained through a "measurement process", thanks to the following consideration: without measuring it's not possible to compare, therefore to estimate the trend of any activity. Consequently, to be able to measure it is necessary to define some indicators. So it is possible to check the intermediate steps of the activity progress in each phase, as well as to measure, check and validate the phases of the process.

Therefore the definition of a specific checking and evaluation tool of the reached performance levels is, at the same time, the check of the fulfilment level of the foreseen objectives. It is expressed clearly with the process of energetic-environmental certification of the lighting systems, put at the end of each phase as indicated: certification of the planning phase, certification of the realisation phase, certification of the management and maintenance phase and certification of the divestment phase.

6.2 The compensation principle

The measure of the fulfilment level of the objectives is the basis of the compensation principle. It is the performance level of the urban lighting system. The nature and the aim of this principle can be understood after considering: the role of lighting in the process of urban upgrading and the role of lighting in the energetic sector. Moreover it is useful to reassert that, as above-mentioned, the programme of urban lighting concerns short-term actions, arranged between the public-private parts. This is expressed by the chance to leave to the private subject the total or partial realisation of the urban lighting system. These considerations also express the possible situations that could occur in the urban field.

1. Inside the upgrading programmes of the fabric of the city, the system of empties, or rather of the public space, can become an intervention object of the private. This activity can be applied compensating for the expense through the award tool. This principle requires two instruments. One of guide, typical of the planning phase, and made explicit by the lighting programme. The other, of check, is carried out at the end of the process phases involved in the operation. This system is necessary to guarantee the fulfilment of

the public objectives, formerly defined. At the same time, the concept of award implies a measuring of the fulfilment level of the objectives. On this point the energetic-environmental certification, assuming the estimation of the performance fulfilment level from A to G, can be a useful instrument to measure the award. The bigger the certification class, the bigger the advantages for the local government, in terms of quality of lighting system and, consequently, the bigger the advantages for the private subject involved. During the planning phase the local government has to define the certification criteria, as well as the awards ones.

2. Inside the upgrading programmes of the lighting systems, carried out thanks to loans from third party (FTT), the same practical procedure above-mentioned can be applied. Actually, even if the aims of the public part remain the same in both cases, the private ones significantly change. In fact, the private engaged in a urban upgrading process, after the decision to intervene on the public space, finds the chance to reach a system of reductions to keep on the real estate. Moreover, it has a pay back return of investment even in terms of general image of the urban environment which, therefore, will give more value to the operation. The private engaged to finance the total or partial upgrading and/or realisation of the urban lighting systems, finds profitability in the investment, if characterised by a very moderate risk and by a substantially constant cash flow originated by the energetic saving achieved. This allows this subject to be rewarded against the costs of the system planning, installation and management met in a reasonable time. It’s clear that this latter subject considers the energy conservation the fundamental requisite of the intervention. The tools above stressed become assumption for arrangement between the parts.

6.3 Certification systems of the energetic-environmental quality of the lighting systems in the phases

The check method of the performance level fulfilment has been found in a score rating system. In this system to each satisfied requirement a score is given which contributes to fix a general score, exemplifying the reached performance level. The system is structured on a list of requirements, grouped in areas of evaluation, and to each of them an evaluation judgement in numerical scale (score) is assigned, related to the conformity degree to the benchmark. In fact, the assignation of the score to each requisite occurs through the definition of the corresponding performance indicators and, consequently, of the criteria necessary to the check of the fulfilment level of these performances. The evaluation scale is structured through a corresponding chart between a value scale that goes from –2 to +5 and the criteria of score assignation, where the zero is the value or the benchmark concerning what can be considered as the current realising practice, with observance of the current laws and regulations. The score rating system adopted also considers synergetic awards if the requisites regarding a specific family, are satisfied all or, in significant percentage. The synergy award is a clear signal that shows that the best results are not given by the addition of single actions, but by a global and organic strategy. Moreover, the single requisites had importance in the belonging evaluation areas, according to a preventive assignation of the importance that each has. It emerges a sort of energetic-environmental report card and, through a pondered summation of the reached score for each considered requisite, it's possible to obtain an exemplifying global score of the performance level of the installation in exam. This evaluation is carried out for each phase of the process (planning, execution, management and divestment) and it defines a series of single or summable certificates, making a sort of quality label. The total score contributes to give a certification level according to the classes: A,B,C,D,E,F,G.

ENERGETIC - ENVIRONMENTAL CERTIFICATION IN DESIGN PHASE												
CLASSES OF REQUIREMENTS GROUPPED IN AREAS OF EVALUATION		score								►	weight	score
1.U	**NIGHT AND DAY URBAN ENVIRONMENTAL PERFORMANCE**	-2	-1	0	1	2	3	4	5		tot 1	
1.U1	safety of people	demanded										
1.U2	wellbeing and visual comfort	-	-									
1.U3	wellbeing and chromatic comfort											
1.U4	contest adaptability											
1.U5	quality of lighting spaces											
2.A	**ENERGETIC-ENVIRONMENTAL PERFORMANCE**	-2	-1	0	1	2	3	4	5		tot 1	
	MATERIALS AND RESOURCES											
2.A1	use materials renewable or recyclable											
2.A2	resources re – use											
2.A3	waste management											
	ENERGY											
2.A4	reduction of energy consumption											
2.A5	maximization of renewable energy resources consumption											
2.A6	implementation of use technological solutions energy-saving oriented											
	LIGHT POLLUTIONS											
3.T	**TECHNOLOGICAL PERFORMANCE**	-2	-1	0	1	2	3	4	5		tot 1	
3.T1	safety of systems	demanded										
3.T2	controllability of systems and maintenance of performance	demanded										
3.T3	engineering											
3.T4	integration with other systems											
3.T5	usability	demanded										
3.T6	flexibility and adaptability	demanded										
3.T7	functionality	demanded										
4.P	**PROCESS PERFORMANCE**	-2	-1	0	1	2	3	4	5		tot 1	
4.P1	design process performance	demanded										
4.P3	maintenance process performance	demanded										
4.P4	planning and implementation of information system											
5.E	**ECONOMIC PERFORMANCE**	-2	-1	0	1	2	3	4	5		tot 1	
5.E1	low costs of execution											
5.E2	life – cycle costs											
5.E3	time of execution planning											
5.E4	compatibility with other installations											
		TOTAL										

Figure 5: The matrix of scores

The energetic-environmental certification of the lighting system is given during the planning phase if the score total is included between the following limits:

range of score	class	color associated
>105	**G**	
88-105	**F**	
70-88	**E**	
55-70	**D**	
36-55	**C**	
18-36	**B**	
2-18	**A**	

case	Soggetto Proponente	Design phase	certification	Execution phase	certification	Management and maitenance phase	certification	Divestment phase	certification	Certification level						
										A	**B**	**C**	**D**	**E**	**F**	**G**
										Award level						
										P_A	P_B	P_C	P_D	P_E	P_F	P_G
1.	designer		✓													
2.	contractor				✓											
3.	contractor						✓									
4.	contractor								✓							
5.	contractor		✓		✓											
6.	contractor, utility, ESCO		✓		✓		✓									
7.	contractor, utility, ESCO		✓		✓		✓		✓							
8.	contractor, utility, ESCO				✓		✓									

Figure 6 - 7: Classes of certification and the certification matrix in the phases of the process

7. Conclusions

The bottom strategy top down uses a operational model represented according to a reiterated process, which requires phases of closer examination alternate to check cycles to the different scales and phases of intervention. It requires a division in activities for each phase: analysis, definition of the objectives (requisites, performance specification), individuation of the solutions, check and evaluation of the performance level. The definition of given procedures, able to systematise the activities and the criteria of acceptance of each phase is a support able to assure a correct application of the same. These latter become application of the criteria fixed by the light masterplan (planning instrument of the interventions and of the certification criteria, that is of the minimum acceptable performance levels and of the possible ones). Finally they become as assumption for the evaluation and check of the application performance levels.

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Sustainable Procurement: Is Partnering the key?

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Abstract

Partnering has been cited as a means to deliver sustainability through the procurement system. This idea builds on the notion that sustainability and partnering have the same ethos of long term goals and mutual benefit. Sustainability is often seen as intangible and difficult to deliver at project level. There is often agreement at policy level as to the meaning of sustainability. However there is a common concern that sustainability is difficult to identify and therefore deliver through a construction project. By adopting a more appropriate procurement route sustainable development may become more achievable.

Research had been conducted in the context of the UK social housing sector, with its requirement for a move towards partnered procurement. The research sought to establish how frequently partnered procurement is taking place and how appropriate it is considered for the delivery of sustainability. The research focuses on the procurement selection and how this impacts on the sustainability of a project. Significant features of a partnering framework are identified to create a profile of partnering at project level.

A national survey of social housing providers investigates the attitudes towards partnered procurement. The results of these surveys are analysed to demonstrate the approach to procurement selection and the attitudes that are most commonly linked to the choice of partnering as a procurement route. This research provides a comprehensive snapshot of procurement selection practice and the relationship this has with the delivery of sustainable housing projects. There is a general consensus that partnering can deliver sustainability and that partnering is a more suitable form of procurement to achieve this rather than more traditional procurement routes. This research suggests that further longitudinal studies are undertaken to measure the long term performance of projects that are undertaken using partnered procurement.

Keywords: Sustainability, Procurement, Partnering

1. Sustainable Procurement

1.1 Overview

The research presented in this paper is part of a larger piece of research involved in the concept of sustainability and procurement of social housing. The social housing sector in the UK is obliged to consider sustainability when procuring new housing project. Partnering is often suggested as the most appropriate procurement approach to achieve improvement through the construction of building projects. This research considers the procurement of social housing and reports on research conducted with development managers of Registered Social Landlords (RSLs). Attitudes towards various procurement approaches was established to explore the link between partnering and the delivery of sustainability.

1.2 The Context of Partnering

A recurrent theme from the Rethinking Construction agenda is partnering and integrated teams. According to the Construction Best Practice Programme (CBPP), the two principles that embody best practice in construction are the abandonment of lowest capital cost as the value comparator and involving specialist contractors and suppliers in design from the outset. Partnering lies at the heart of the 'Rethinking Construction' agenda. Partnering is being advocated by the Housing Forum and the UK housing agencies as a means to deliver improvement through the procurement of social housing. Partnering is heralded as a means to achieve this supply chain integration.

The interpretation of partnering takes two forms. One, of a philosophical position or framework, and another a form of contracting. There is a difficulty in finding absolute agreement at a detailed level as to what partnering is and hence it may be applied to various forms of alliancing (Liu and Fellows 2001). Masterman (2002) defines partnering as a “discretionary system” of procurement. It is described as:

> *a means of administering and establishing an environment within which a project is implemented using any of the available procurement systems to carry out the funding, design, construction etc. of the project, although some systems work better with partnering than others.*
>
> (Masterman 2002:135)

This implies that it is not a form of procurement but a framework within which procurement takes place. This view is supported by the numerous definitions of partnering found throughout the literature. The CIB (1998) definition refers to a *management approach*. The CII (1991) talks about *long term commitment*. Culture change is a common theme, having significant importance to organisations planning to embark on a partnered approach to procurement. This change is necessary to move away from the entrenched exploitive and adversarial ways found throughout the construction sector to a more collaborative way of operating (Fisher and Stuart 2001).

There are two types of partnering. Project partnering where the relationship is put in place for one specific project and strategic partnering where there is a long term/ multi project arrangement. It tends to be stated that there is more benefit to be gained from strategic partnering although an acceptance that project partnering is most likely to be embarked upon by those new to the concept. There is consensus in the literature on the attributes of successful partnering. They include trust, mutual objectives, collaboration, equality, continuous improvement and agreed problem resolution. It is interesting to note that in a survey of construction professionals "failure to build a trusting relationship" was muted by a third of respondents as a barrier to partnering (Murray *et al.* 1999).

There is much less agreement on the processes of partnering. Partnering emerged in the UK construction industry at the beginning of the 1990s, and because of the relatively young nature of the concept there is not a large body of empirical research. A survey of contracting practices carried out on behalf of the RICS in 1998 revealed that only 1.7% of projects was carried out under partnering agreements. Partnering and collaborative working are not sufficiently evolved and researched to be able to draw lessons from past experience. Much of the evidence presented in research papers is anecdotal or based on a small sample.

Partnering in the social housing sector (ECI 2000) presents a prescriptive approach to partnering that can be used as a checklist of actions. The key objectives of partnering in the social housing sector are identified as *cutting out waste, increased predictability, secure life-cycle cost benefits and increase innovation.* There is little mention of culture change and philosophical position. Culture is identified as the main barrier to implementing partnering. There is recognition in most of the literature that both philosophical and process definitions are relevant and constitute an important aspect of partnering.

Partnering has been said to be capable of delivering up to 30 % cost savings (Bennett and Jayes 1995) over traditional sequential procurement. This figure relates to a programme of strategic partnering and is somewhat ambitious having not been supported by sufficient evidence to draw any firm conclusions. There is a growing body of anecdotal case study material that presents positive feedback from a partnered procurement route.

The CIB (1997) state that the benefits are significantly greater if partnering is applied throughout the supply chain. Integrated teams and supply chains although often written about separately are in fact a manifestation of partnering and one could argue partnering applied in the most comprehensive way possible. If clients really intend to unlock the potential of the supply side they will have to start projects entirely differently. This means assembling alliances of consultants, specialists and key manufacturers into integrated teams. Martin Davis of the Integrated Team Working Group states that if this is achieved **“**The supply side should be expected to drive and deliver on challenging performance targets”. He also emphasised the importance of research and development. "The supply side should welcome researchers working within integrated teams to help it monitor and improve its performance. Those universities and institutions supporting continuous improvement in the industry's key success areas should be given priority financially."

The Rethinking Construction report, *Accelerating Change* (Strategic Forum for Construction 2002) proposes that 20% of all construction projects have an integrated team and supply chain by 2004. It is not known if this figure has been achieved. It further states that *every link of the supply chain has a critical contribution to make towards sustainable construction and development.*

1.3 Sustainable Development

The construction industry has been identified as one of the most important areas for implementing sustainable development. The built environment is seen to have a significant impact on sustainability issues. In 1999, 50% of the UK’s CO_2 emissions were produced by energy use in buildings (M4I 2000). *Building a Better Quality of Life* (DETR 2000) places construction at the heart of the UK government sustainable development agenda. It claims that the construction industry has a huge impact on the quality of life in the UK and that considerable economic, social and environmental benefits can be drawn from a more sustainable construction industry.

The CBPP states that the client has a key role to play in the delivery of sustainable construction owing to their position within the construction supply chain (CBPP 2002). They are able to influence decision-making on how the construction process impacts the broad themes of environmental, social and economic sustainability. The client can demand forms of and encourage actions towards sustainable development with a clear value statement that guides all procurement activity. Quality, whole life costing, best value and people issues all make their contribution to the overall sustainability of a development.

Scottish Homes *Sustainable Development Policy* (2000) focuses on four key actions:

- Improving the thermal performance of housing
- Reducing the need for physical resources
- Influencing the location and mix of housing
- Raising and improving consumers awareness

Improving the thermal performance of housing has three chief benefits: To reduce CO_2 emissions, condensation and fuel poverty. Housing that is designed and constructed to minimise energy use in occupation has the ability to improve the occupant’s health and well being and reduce the devastating effects of fuel poverty. Housing Associations may consider the benefits accrued in terms of lower maintenance attributed to condensation and higher levels of tenant satisfaction.

The clients influence on the procurement process has the potential to address many of the failings of the construction in relation to long term sustainability. It is estimated that 30% of construction is re-work and only 40-60% of labour time is used efficiently. This incorporates substantial waste into the construction process. Eliminating this waste will have impacts not only in terms of environmental sustainability but also in terms of direct cost and time reduction and increased motivation and satisfaction across the team. Collaborative working is seen as an essential means to addressing this problem.

Brownfield site regeneration and redevelopment of existing buildings are both seen as sustainable options. The choice of site is one of the first steps in the procurement process and has far reaching implications in terms of community sustainability. At a micro level adaptability and mix of tenure in a housing development have a significant impact. Strategic planning and development, a product of collaborative working will have a significant role to play.

2. Linking Partnering and Sustainability

The Housing Forum sought to encourage partnering through the procurement process. Partnering is now central to the housing agencies' strategies for improving procurement of social housing. It has been suggested that the attributes of partnering are essential pre-conditions of achieving sustainable construction (Addis and Talbot 2001). HAs and their consultants and contractors will have to reach a mutual consensus on the definition of sustainability at project level if it is to be achieved within the overall procurement process. There is a need to link the policy, regulation and guidance to respond to the individual project circumstance.

In theory the difficulty in meeting the holistic goals of sustainable development policies is evident at project level. The ability of short term project objectives to address the long term altruistic goals of sustainability is limited. In practice evidence of creating buildings with one sustainable feature demonstrates a myopic rather than holistic approach to sustainability. Social housing projects have a requirement to demonstrate sustainability, yet the people involved in their procurement have a varied understanding of the term.

2.1 Methodology

A study of Registered Social Landlords (RSLs) was carried out to establish an understanding of sustainability and partnering within the social housing sector. The research tool selected was the questionnaire. This was chosen due to the size of the survey population. There are over 2300 housing associations within the United Kingdom. One of the main aims of the survey was to establish trends across the whole social housing sector.

The survey was conducted amongst the UK population of RSLs. 990 housing associations involved in development of social housing were selected for inclusion in the survey. Those that owned less than 20 properties were immediately eliminated from the survey population. This left a sample of 1090. One third of these organisations was contacted and invited to complete the survey. The questionnaire was supported by a letter addressed to the 'Development Manager'. A low response rate of 25% was achieved which was considered inadequate. A second round of questionnaire was sent out which raised the response rate to 37%.

The raw data were compiled within a Microsoft Excel spreadsheet and then imported into Statistical Package for Social Scientist (SPSS) to conduct the analysis. The questionnaire was concerned with the collection of perception in the subjective areas of sustainability and partnering. Attitudinal measuring scales were used to provide a number of options for the respondent to select. Composite measurement of an issue or ranges of issues is suggested (Wilson 1996). This involves asking more than one question on a similar area in order to develop a theoretical construct. It is used to gauge the link between sustainability and approaches to procurement. Two questions are strongly correlated and the responses can be used to construct a more accurate view on the issue.

2.2 Results

The results of the questionnaire provide a snapshot of the partnering activity that is taking place in the social housing sector. It also provides the general perception of the way in which procurement approaches are related to the concept of sustainability. The results provide the contextual background against which procurement decisions are being made.

It was found that a higher proportion of RSLs were engaged in partnering than not. The most common form of partnering was 'Project' partnering with consultants and contractors. Almost forty percent of RSLs were in partnerships with other RSLs (housing associations). The least common partnering was with sub-contractors or suppliers.

Strategic partnering was less common than project partnering. The only incidence of strategic partnering exceeding project partnering was the Large RSLs partnering with other RSLs.

Table 1: Incidence of Partnering in Social Housing Procurement (% of respondents)

	Split into small med large	**Strategic Partnering**	**Project Partnering**
Consultants	**Small HAs**	2	6
	Medium HAs	19	20
	Large HAs	22	36

	Total	43	62
Contractors	**Small HAs**	2	4
	Medium HAs	13	24
	Large HAs	24	42
	Total	39	70
Subcontractors	**Small HAs**	2	2
	Medium HAs	9	12
	Large HAs	11	13
	Total	22	27
Suppliers	**Small HAs**	2	2
	Medium HAs	9	11
	Large HAs	15	19
	Total	26	32
Other RSLs	**Small HAs**	4	6
	Medium HAs	15	20
	Large HAs	24	21
	Total	43	47

Traditional contracting, Design and build and Partnering were presented to the respondents as three procurement approaches. The respondents were asked to judge the strength of agreement with the statement in terms of the link held with sustainable development. The question was designed to gauge if the concept of sustainable development was perceived to relate more closely to any of the proposed procurement approaches. This allowed the respondent to provide a response based on 'gut-feeling' rather than in relation to specific experience. The data was collected with the use of a five-fold Likert scale. The scale ranged from *strongly agree* to *strongly disagree*. A central or neutral position was described as *uncertain*. Although this allowed the question to remain in effect unanswered it allowed a respondent to demonstrate lack of knowledge or experience in this area.

Table 2: Correlation of partnering experience and perception of procurement approaches

		Partnering		Design and Build		Traditional	
Project Partnering – Link with Sustainability	Consultant	.368	.002	.242	.083	.231	.103
	Contractor	.369	.001	.254	.054	.281	.030
	Sub-contractor	.611	.000	.306	.079	.288	.092
	Suppliers	.420	.002	.296	.058	.323	.188
	Other RSLs	.362	.009	308	.024	.235	.124
Project Partnering – Ability to deliver Sustainability	Consultant	.405	.002	.311	.015	.317	.022
	Contractor	.415	.001	.328	.008	.325	.000
	Sub-contractor	.556	.000	.385	.021	.373	.027
	Suppliers	.422	.004	.354	.021	.306	.074
	Other RSLs	.419	.004	.374	.006	.299	.043
Strategic Partnering – Link with sustainability	Consultant	.404	.001	.270	.065	.188	.249
	Contractor	.429	.001	.257	.077	.179	.264
	Sub-contractor	.633	.000	.373	.030	.239	.195
	Suppliers	.574	.000	.356	.023	.273	.106
	Other RSLs	.404	.002	.294	.043	.221	.162
Strategic Partnering – Ability to deliver sustainability	Consultant	.448	.001	.369	.010	.343	.018
	Contractor	.465	.000	.311	.025	.330	.021
	Sub-contractor	.584	.000	.530	.000	.397	.019
	Suppliers	.619	.000	.514	.000	.412	.007
	Other RSLs	.436	.001	.323	.027	.295	.049
Note: shaded cells indicate no statistical significance							

It was assumed that partnering practice would have an influence on the perception of the approaches to procurement and their link to sustainability and whether they are able to deliver sustainability. Each form of procurement was correlated with the types of partnering that had been undertaken by a respondent RSL. Strong correlation coefficients indicate that experience of partnering practice has provided a more positive view of a procurement approach and its link or ability to deliver sustainability. The coefficients and statistical significance are presented in table 2.

Without exception, all those that had experience of partnering agreed that partnering had a link to sustainability and it could deliver sustainability. Although this result is an expected result, it does confirm that the perceptions of partnering are borne out in practice. The strongest correlations were found in respondents that had partnering experience with sub-contractors and suppliers.

The correlation between traditional contracting and partnering experience generated the highest number of correlations that were not statistically significant. Those with either project or strategic partnering experience generally rejected the link between traditional contracting and partnering.

There was a moderate increase in respondents agreeing the link between design and build and partnering, although most of the agreement came from respondents with strategic partnering experience.

Experience of partnering appears to provide greater confidence in its ability to deliver sustainability as opposed to design and build or traditional contracting. The greatest confidence correlations were evident in RSLs that had partnered with sub-contractors or suppliers. This seems to support the view that the supply chain is critical to the delivery of sustainability conceptualised.

3. Conclusions

This study is part of a larger piece of research investigating the way in which sustainability is understood at policy and practice level in the social housing sector. Selection of procurement approach is a fundamental decision within the construction of a social housing sector. The requirement to deliver projects that demonstrate sustainability has changed the focus of decision making. The ultimate choice depends on a great number of factors including past experience. The RSLs with experience of partnering have far greater confidence in a partnered approach to procurement than a design and build or traditional route. This leads to the conclusion that where sustainability is a strong factor, there is going to be a greater liklehood of partnering being selected. This research is not able to confirm this view, but suggests that further research is required to establish the effect sustainability has on the ultimate choice of procurement approach.

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Factors affecting the effectiveness of performance based standards in Singapore

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Abstract

The objectives of this research are: (1) To identify the factors limiting the effectiveness of performance based (PB) standards; (2) To compare the views' of the industry and the Building Construction Authority (BCA) on performance based standards; and (3) To recommend the most significant factors for consideration in understanding and assessing the factors' effectiveness on performance based standards. The research methodology employed in the study consisted of a questionnaire survey. Data were collected from developers, contractors, consultants and suppliers. Results showed that the awareness level of the construction industry was poor and seven factors have been identified which are significant in limiting the effectiveness of at least one type of benefit accrued to PB standards. Findings from this study will enable the regulatory body to focus on the impact of these seven limiting factors in formulating implementation polices for performance based standards in the construction industry. Furthermore, this study will help to create greater awareness among the key parties in the construction value chain on the issues of performance based standards. Effectively, knowledge acquired by the industry will then maximize the potential of the performance approach.

Keywords: Performance based standards, effectiveness, awareness, regulatory body

1. Introduction

The performance based approach is a radical departure from the conventional procurement system in Singapore. The government's push for a performance based concept is exemplified by repealing the previous prescriptive regulatory system with a performance based regulatory system in January 2004. Although, it has been established extensively in studies by overseas researchers that there are more advantages to be derived from adopting a performance based approach than a prescriptive approach, researchers also found that there are factors that would limit its effectiveness.

One of the key reasons for the growing importance of the performance based approach is its ability to transcend barriers to trade within the international construction market. The performance concept has been implemented in developed countries like the United Kingdom in 1987, New Zealand in 1992 and Australia in 1994 but with varying levels of success [1]. The limited success of the performance based regulatory system can be attributed to the fact that the overall system has not been addressed and deficiencies in key areas like education and infrastructural support [2]. Therefore, it is imperative that knowledge of such issues is shared with the local industry so as to maximize the potential of the performance approach. Hence, it is the intention of this study to explore and determine the factors limiting the effect of performance based standards. In addition, the findings and generated models of this study will provide the parties involved in making strategic standardization decisions to make better decisions with respect to their requirements.

The objectives of this research are: (1) To identify the factors limiting the effectiveness of performance based standards; (2) To compare the views' of the industry and the Building Construction Authority (BCA) on performance based standards; and (3) To recommend the most significant factors for consideration in understanding and assessing the factors' effectiveness on performance based standards.

2. Research Method

A sample survey was used to gather the necessary information required for this study. In order to obtain an overall view of the effect of performance based standards on construction industry, four groups of target respondents were selected for the study. They included the developers, contractors, consultants and suppliers.

The source of contacts for contractors and suppliers were from the Building Construction Authority (BCA), Directory of Registered Contractors, 2004 edition. In the case of developers and consultants, they were selected from the Real Estate Developers' Association of Singapore (REDAS) website and the Singapore Institute of Surveyors and Valuers (SISV) website respectively.

A total of 250 electronic copies of the questionnaire were sent out to the various participants to gather the required data for analysis. These comprised 30 developer firms, 120 contractor firms, 30 consultant firms and 50 suppliers. The distribution pattern of the sample ensured that equal attention was paid to both the contractors and non-contractors. Questionnaires were emailed to the firms, and returned via the same routes. The survey was conducted from October 2004 to December 2004, and respondents were given three month to complete the questionnaires.

The questionnaire design consisted of four sections to facilitate data collection. Section A asked general questions to determine the characteristics of the respondents. Section B asked respondents about the factors affecting the implementation of performance based standards. On a scale of 1 (which represents strongly disagree) to 5 (which represents strongly agree), the respondents were requested to indicate the impact level of the factors during implementation in

Singapore. Section C, provided a list of benefits of using the performance based standards which the respondents have to rate on a scale of 1 (which represents strongly disagree) to 5 (which represents strongly agree). Lastly in Section D, the respondents had to rate a list of recommended measures implemented in construction industry to encourage the use of performance based standards on a 5-point scale where 1= strongly ineffective and 5= very effective.

3. Data Sample Characteristics

230 survey questionnaires were emailed to the various participants in the construction industry. A total of 30 forms were returned, giving an overall response rate of 12%. Among these, 15 responses were not usable as respondents were not aware of the performance based regulatory system that was already in placed. The profile of respondents is shown in Table 1. Construction firms formed the majority of respondents.

The respondents' profiles indicated that they were suitable and qualified to participate in this study. Furthermore, the wide spectra of designation of respondents which range from directors to student interns, is a good indicator of the level of awareness of the Performance Based Regulatory System (PBRS) within the industry.

Table 1: Characteristics of respondents

Respondents' characteristics	Total surveys sent	Total surveys received	Unusable surveys	Usable surveys
Nature of firm (predominant)				
Developers	30	3	-	3
Construction firms	120	14	9	5
Consultants	30	8	3	5
Suppliers	50	5	3	2
Total	230	30	15	15

4. Results and Discussion

The one-sample t test was first used to test the three areas in concerned: whether the limiting factors, benefits of performance based standards and measures to encourage usage of performance based standards are significant. Multiple linear regression (stepwise) is then used to generate six models – one of each benefit of performance based standards.

4.1 Factors Limiting the Effectiveness of Performance Based (PB) Standards

The one-sample t test is first conducted on the factors limiting the effectiveness of performance based standards (Table 2). All the factors except for the F8.10 (greater competition from foreign companies) have $p > 0.05$ and therefore it is concluded that these ten factors have an impact on the effectiveness of PB standards based on $\alpha = 0.05$.

The survey questionnaire was also emailed to the Building Construction Authority (BCA). A ranking on the level of agreement on the factors that limits the effectiveness of PB standards was carried out to compare the differences between BCA and the industry's views. It was found that both parties (BCA and the respondents) generally agreed that F8.1 (lack of performance indicators), F8.6 (lack of research and development in the field of PBRS) and F8.7 (liability issues of using PB standards) have an impact on the effectiveness of PB standards. These results were not uncommon and had been well established by past studies [3, 4, 5]. Hence, it is pertinent that Singapore should attempt to address such issues on an international basis, thereby tapping onto the expertise of other countries which are more advance in the use of PB standards which requires more technical knowledge to develop and apply than prescriptive standards.

However, there were differences in views for the regulatory body (BCA) and the respondents from the industry for F8.2, F8.4, F8.5, F8.9 and F8.11. This could stem from the fact that companies in the industry are ill informed of the developments of PB standards. There should be more promotion and seminars for the newly enacted regulations especially to the smaller firms in the industry which makes up the bulk of the industry. In 2000, BCA conducted a survey to gather the industry's feedback on the proposed change from a prescriptive environment to a PB environment and the survey results indicated a positive response from the industry. However, the survey results obtained in this study (as highlighted by the views of respondents for F8.4 and F8.9) seemed to suggest otherwise. In addition to a re-evaluation of the perception of the industry on PB standards, this survey also attempts to determine the possible factors limiting the effectiveness of PB standards (see Table 2). The findings of this study would enable BCA to be more aware of the impact of these factors during the formulation of implementation policies for the industry.

Table 2: Summary of One Sample t-Test results to identify significant factors

Label	Factor	Test Value = 3		Ranking (Mean)	
		Sig (1-tailed)	t*	Industry	BCA
F8.1	Lack of performance indicators	0.000	4.525	3 (3.93)	10 (1.00)
F8.2	Uncertainty involved in the use of PB standards	0.001	4.090	3 (3.93)	5 (2.00)
F8.3	Lack of knowledge to use PB standards	0.000	6.959	1 (4.07)	1 (4.00)
F8.4	Lack of support from parties within the construction chain	0.001	4.026	5 (3.87)	5 (2.00)
F8.5	Higher cost implications in using PB standards	0.006	2.870	6 (3.67)	10 (1.00)
F8.6	Lack of research and development in the field of PBRS	0.002	3.568	6 (3.67)	1 (4.00)
F8.7	Liability issues of using PB standards	0.000	5.292	6 (3.67)	1 (4.00)
F8.8	Lack of incentives to be innovative	0.041	1.871	11 (3.27)	4 (3.00)
F8.9	Hard to change the mindset of clients and other parties in the construction	0.000	4.583	2 (4.00)	5 (2.00)

	industry				
F8.10	Greater competition from foreign companies	0.119	1.234	9 (3.33)	5 (2.00)
F8.11	Inability of PB tests to relate to actual performance	0.002	3.568	10 (3.53)	5 (2.00)

* The one sample t-Test excludes the survey results from BCA.

4.2 Benefits of Using of Performance Based Standards

Respondents were requested to rate the benefits of using performance based standards (see Table 3). All the benefits except for the B9.2, B9.3 and B9.4 have $p > 0.05$, therefore it is concluded that these three benefits (B9.1, B9.5 and B9.6) that are accrued from the use of PB standards are significant based on $\alpha = 0.05$.

A comparison of views between BCA and the respondents was conducted and the results are largely similar except for B9.3 and B9.4. The main reason for this difference could be due to the nature of the local industry. The Construction 21 report has identified the intense competitive bidding environment of the industry as a potential obstacle to the progress of the industry. Clients' preference for the lowest bid has resulted in an unhealthy focus on price and inevitably, quality of works decreased which would result in greater number of defects.

Table 3: Summary of One Sample t-Test results to identify significant benefits

Label	Factor	Test Value = 3		Ranking (Mean)	
		Sig (1-tailed)	t*	Industry	BCA
B9.1	Higher quality of workmanship.	0.034	1.974	3 (3.47)	2 (4.00)
B9.2	Reduce cost of construction.	0.151	1.075	6 (3.27)	6 (3.00)
B9.3	Greater client satisfaction.	0.056	1.702	4 (3.40)	1 (5.00)
B9.4	Reduce defects problems of buildings.	0.068	1.581	5 (3.33)	2 (4.00)
B9.5	Greater flexibility to promote innovation.	0.000	6.089	1 (3.93)	2 (4.00)
B9.6	Increasing the global competitiveness of the company.	0.002	3.568	2 (3.67)	2 (4.00)

* The one sample t-Test excludes the survey results from BCA.

4.3 Measures to Encourage Usage of Performance Based Standards

Respondents were asked to rate the effectiveness of the measures to encourage the use of performance based standards in construction industry (Table 4). All the measures except for the **M10.3** have significant levels that are less than 0.05 and therefore it is concluded that these measures are significant. It is not surprising that M10.3 is not significant as most companies are expected to be unwilling to pay an additional levy on projects when the industry outlook is bleak and profit margins of companies in the industry are already very low.

A comparison of views between BCA and the respondents was conducted and it was found that both parties have differing views for M10.2. BCA is neutral on the idea of establishing a government sponsored body to lead and co-ordinate the construction industry's R&D efforts in PB standards. The possible rationale for this could be that BCA recognize the need for research and development into performance standards but the industry should reduce its reliance on the government and be allowed to mature to start its own initiatives. This view was shared by Dulaimi and Tan [6] who felt that local companies were over dependent on the government to lead the development of the industry.

Table 4: Summary of One Sample t-Test results to identify significant measures

Label	Factor	Test Value = 3		Ranking (Mean)	
		Sig (1-tailed)	df*	Industry	BCA
M10.1	Major players in the industry should take the lead in using PB standards to encourage other firms to use it.	0.000	14	1 (3.93)	1 (5.00)
M10.2	Establish a government sponsored body (Central Standardization Agency, CSA) to lead and co-ordinate the construction industry's R&D efforts in PB standards.	0.000	14	1 (3.93)	3 (3.00)
M10.3	Introduce a levy on all construction projects to fund the Central Standardization Agency.	0.151	14	5 (2.73)	4 (2.00)
M10.4	Subsidies to be given for companies to attend PB standards seminars.	0.001	14	3 (3.73)	4 (2.00)
M10.5	Greater clarity in enforcement issues in a PBRS framework.	0.000	14	3 (3.73)	2 (4.00)

* The one sample t-Test excludes the survey results from BCA.

4.4 Multiple Linear Regression to Determine Industry's Perception on the Factors' Effect on Performance Based (PB) Standards

Using SPSS, stepwise multiple linear regression technique is used to construct six models to determine the extent of respondents' agreement on each benefit accrued due to performance based standards, based on the 11 limiting factors. The Stepwise method will remove insignificant variables and thus only consider the factors that are of significant.

Of the six models generated, the most robust model is for B9.3; it has an adjusted R^2 value of 0.73. In general, the lack of robustness of the other models to determine the extent of agreement for B9.1, B9.2, B9.4, B9.5 and B9.6 could be due to the limited sample size of the survey (see Table 5). Therefore, results in this survey may not be conclusive. Despite this limitation, the survey results nevertheless gave an important insight of the awareness and knowledge of performance based standards amongst the respondents. This would enable the relevant authority like BCA to better understand the current situation in the industry and formulate policies to avoid the pitfalls of implementing the PBRS in the industry.

Table 5: Six Models Generated by Multiple Linear Regression Technique

No	Regression Models	Adjusted R^2
1	B9.1 = -1.462 + 0.867(F8.11) + 0.514(F8.8)	0.457
2	B9.2 = 1.218 + 0.559(F8.5)	0.218
3	B9.3 = -3.339 + 0.828(F8.8) + 0.965(F8.3)	0.730
4	B9.4 = 1.082 + 0.582(F8.4)	0.304
5	B9.5 = 2.159 + 0.451(F8.2)	0.409
6	B9.6 = 7.700 – 1.100(F8.7)	0.515

4.5 Discussion for Regression Model for B9.1

Higher quality of workmanship (B9.1) is expected from PB buildings as meeting performance requirements are a critical aspect of the PB approach. The PB approach allows for innovative means through the use of new technologies and techniques to increase the level of workmanship. But there are insufficient incentives (F8.8) for companies to go beyond compliance despite adopting a PB approach [7]. The more essential factor in affecting the quality of workmanship is the inability of PB tests to relate to actual performance (F8.11); due to its higher coefficient in the regression model. In addition, Cary et al. [7] indicated that PB standards can be imprecise and difficult to measure when they are qualitatively based. Currently, most performance indexes are lab based or results are simulated, they do not reflect actual building performance. One of the ways to overcome this is to have the major players like the Housing Development Board (HDB), Jurong Town Corporation (JTC) or Land Transport Authority (LTA) which have a large pool of buildings, to conduct a research. That is to look into the past records of materials used, testing methods and try to link it to building performance. Furthermore, there should be greater monitoring of such test and results for on going projects; this will facilitate the development of test indexes for actual building performance.

4.6 Discussion for Regression Model for B9.2

The benefit of reducing cost of construction (B9.2) due to usage of PB approach is ranked the lowest by the respondents in this study. The main reason could be that majority of the companies in the industry are small to medium sized companies which are driven by profits for the short run. Based on the survey conducted by BCA in 1999, 70% of the companies have a paid up capital of less than \$0.25 million and annual turnover of less than \$0.50 million [8]. Therefore, the initial increased in time and cost of adopting the PB approach (F8.5) is more than a deterrent for them despite the fact that a PB approach will result in more functional buildings at lower construction costs [9]. Hence, other than creating greater awareness of the PB approach, the local companies should consider formulating business strategies that ensures the survival of the company in the long run.

4.7 Discussion for Regression Model for B9.3

In the PB approach, the clients have the option to choose the balance of performance and cost they are willing to pay. Greater client satisfaction (B9.3) could stem from higher quality and greater value for money in the long run because meeting the performance requirements is paramount in the PB approach [10]. However, the lack of knowledge (F8.3) and lack of incentives to be innovative (F8.8) for using PB standards is impeding progress into this area. Therefore, the requisite infrastructure for the PBRS to thrive must be in place. In particular, for F8.3 which is ranked the highest by the respondents as well as having the higher coefficient in the regression model. Hence, the authority should focus heavily on establishing a local knowledge base for issues relating to PB approach.

4.8 Discussion for Regression Model for B9.4

A PB standard focuses much more attention on defining success and developing measures of success than on identifying failure modes [11], as a result it is capable of reduce defects of buildings (B9.4). However, the benefit of reducing defects is ranked 2nd lowest by the respondents (see Table 3). This could be attributed to the excess capacity of the industry which results in serious price undercutting that would lead to a subsequent loss of quality as contractors are forced to cut corners [8]. As a result, defects would be more likely to surface and disputes between parties would arise. In addition, symptoms of the ‘suicidal’ tender bidding of contractors have also resulted in delays in numerous construction projects as well as collapse of some established construction firms. Thus, the conflicts ensuing from the intense price competition has further segmented the industry, and resulted in a lack of support from parties within the value chain itself (F8.4). Therefore, it is suggested that the major players in the industry like the LTA and HDB take the lead in adopting the PB approach so as to influence the parties down the construction value chain.

4.9 Discussion for Regression Model for B9.5

One of the main reasons the performance based regulatory system was adopted in Singapore was because of the fact that it allows greater flexibility to promote innovation (B9.5). However, Lee and Barret [4] cautioned that it also increases the possibility of generating new or even greater risks compared to using prescriptive standards due to the uncertainty associated with it (F8.2). This uncertainty is mainly due to the nature of the PB approach as well as a lack of infrastructure to support the PB approach [3]. In addition, Theodore [5] pointed out that building clients, contractors and government regulatory bodies lack the basic competence required for expressing, interpreting and monitoring requirements in terms of performance. Hence, in order to encourage mass adoption of the PB approach, the authority must overcome the uncertainties through conducting of seminars to increase the knowledge base on the PB approach and developing adequate infrastructure for the PBRS to thrive.

4.10 Discussion for Regression Model for B9.6

The industry is made up of mainly small to medium sized companies, and as such few of these companies have the neither the capacity nor expertise to export their services [8]. Hence, although the change of regulatory system to a PBRS may increase the global competitiveness of a firm (B9.6), it is unlikely to have any impact on the operations of these small local based companies. In addition, such companies tend to be profit driven, and as the PBRS does not clearly spell out the obligations of parties (F8.7), it would further deter these companies from adopting the PB approach.

5. Overview of Results

Inter-jurisdictional Regulatory Collaboration Committee (IRCC) and CIB Task Group 37 members found out that a PBRS framework that works in one country may not work in another because of the differences in government, politics and culture. Hence, lessons can be learned from other countries but must be adapted to meet the individual countries needs. In retrospect, Ofori [12] noted that the government actions alone are insufficient to achieve the effectiveness of the implementations made to address the problems of the industry. It is clear that there are many measures to be adopted to remedy the issues but the problem is how to implement them successfully. Therefore, this study has determined the impact of the different factors on the six types of benefits accrued to PB standards. Knowledge gained from this study would then be beneficial to the regulating bodies during the formulation of polices to implement the PBRS.

In addition, the findings of this study also revealed that 50% of the respondents are not aware of the new PB regulatory system that is in placed. The industry is made up of mainly small firms therefore efforts must be made to reach out to these firms in order for the new PB regulations to have any positive effect. This new approach requires a radical new mindset of working as it involves greater professional judgment and responsibility from personnel at all different levels. Hence, the relevant authority should step up their efforts in generating greater awareness and creating a knowledge base for the PB approach.

As for the key parties in the industry, this study serves to generate greater awareness of PB standards among the companies within the industry. With a greater understanding of the issue, key players in the industry could then collaborate with the authority to formulate win-win strategies for all parties. Most of the benefits will only occur if the industry is used to working with the performance based concept and benefits will be maximized if the PB approach is applied throughout the building process [13]. Therefore, companies within the industry should be well informed of the developments in the performance approach as it would have an impact on their operations. The local market is shrinking and competition is intensifying hence the PB approach would increase the global competitiveness of the company.

6. Summary

Extensive research has been conducted on the advantages and disadvantages PB standards. In general, a successful implementation of the performance approach will increase companies' global competitiveness as well as raised clients' satisfaction through higher quality of buildings. However, there is a dearth of local research being done on the factors that limits the effectiveness of PB standards in spite of its growing importance. In view of this, this study was conducted to examine the factors' that contribute to the effectiveness of PB standards in the local industry. To fulfil this, the following issues were investigated.

Firstly, a review of past literature was conducted to provide the background framework of the PBRS that is implemented in Singapore and also to establish and identify pertinent factors having an impact on the effectiveness of the PBRS. Consequently, 11 factors were adopted for use in this study as potential limiting factors. The list of limiting factors and the benefits accrued to PBRS provided the foundation for a retrospective questionnaire.

Secondly, surveys were emailed to key parties in the construction value chain which include developers, contractors, consultants and suppliers. The companies were randomly selected from the REDAS website, SISV website and the BCA, Directory of Registered Contractors, 2004 edition.

Thirdly, the effects of the 11 factors on the effectiveness of PB standards were studied. The one-sample t test was conducted to determine the significant factors. A comparative ranking analysis was also conducted to determine any major differences in opinions between the regulating body (BCA) and firms in the industry based on the same questionnaire.

The findings of the one-sample t test indicate that all the factors except for F8.10 (Greater competition from foreign companies) are significant based on $\alpha = 0.05$ on a 1 tailed test. The result allows us to concentrate on the significant factors for this study. Similarly, the one sample t-test identified three significant benefits that can be derived from the use of PB standards. The use of Stepwise Multiple Linear Regression technique enables the automatic removal of insignificant variables therefore, despite the results obtained from the one sample t-tests; all the variables are included in the regression analysis.

Lastly, six models were generated using the stepwise regression method; one for each benefit accrued to the use of PB standards. This is to identify the factors having the most significant bearing on the effectiveness of PB standards. Attention can be given to the most important factors as identified by the model in order to maximize the effectiveness of PB standards. The stepwise procedure identified seven significant factors (F8.2, F8.3, F8.4, F8.5, F8.7, F8.8 and F8.11; refer to Table 2) that were associated with at least one of the six benefits of using performance based standards.

7. Conclusion

This study is useful in two main aspects. Firstly, it establishes those seven factors that are significant in limiting the effectiveness of PB standards in Singapore. In addition, it attempts to clarify the differences in viewpoints between the regulatory authority (BCA) and the parties in the industries. This serves to provide a greater appreciation of the limiting factors of the PB approach and its associated benefits. Secondly, it established a framework for determining the extent of respondents' agreement on the benefits accrued due to PB standards, based on the 11 limiting factors.

The findings of this study have provided the regulating authority with a greater understanding of the potential obstacles of the performance approach and the likely benefits that can be reaped. It can be said that there is no one model that fits all systems; therefore, careful planning must be carried out in the implementation of policies. More essentially, the authority should obtain feedback from the industry in order to create a win-win situation for all parties.

The importance on PB approach is best exemplified by the increasing attention that has been placed on sustainability and efficiency in the 21st century; the PB approach offers an alternative solution to attaining these two goals. The PB approach also enables the vertical and horizontal integration of the industry which allows for greater communication and integration of the industry. There will be a radical change in the method of procurement and consequently, the PB approach will enable the industry to mature and improves the current level of productivity which is one of the Construction 21 objectives.

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Performance Based Building

Prescriptive building practice is still predominant in many countries. There is evidence that such practice inhibits innovation during the development and the use of built environments. By contrast, Performance Based Building (PBB) fosters innovation through the setting of performance requirements. At their best, these requirements provide challenging fitness for purpose parameters for the whole life span of built environments. Thus, the focus of PBB is on potential ends rather than definite means.

The European Commission funded Performance Based Building (PeBBu) Thematic Network has been a four year programme. It has been a multi-national venture involving many research scientists and industry practitioners. The PeBBu network has aimed at international dissemination and implementation of PBB throughout the development and use of built environments. The main results of this ground-breaking pan-European endeavour are presented in this book.

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Preface

The use of ICT in project based industries such as construction is maturing fast. It is seen as a catalyst for change and an enabler for better planning, monitoring and control of construction and facilities management activities. Nevertheless, there is much that remains to be done as the construction sector exhibits a set of key characteristics that differentiate it from other sectors as reported by Hannus et al. [1] and Kazi and Charoenngam [2]:

- The sector is heterogeneous and highly fragmented, depending on a large number of very different professions and firms, which are mostly small in size, tend to respond to local market needs and control only one element of the overall building process.

- Construction is one of the most geographically dispersed sectors with marked regional differences.

- Construction is highly project oriented. Any ICT used within a project must be deployable and profitable to all / several partners.

- Each construction project, whether to create a new facility or a renovation/repair project is typically unique. The final product tends to be very durable, lasting 25-50 years and longer, and represents one of the few non-transportable industrial products.

- When construction facilities become obsolete they are most often repaired, modernised and sometimes radically transformed to suit new requirements rather than disposed of and replaced with new, which is more typical for manufactured products.

- The sector is highly regulated. Regulations and standards are more rigorous in construction than in most other sectors of economy, with the involvement of several levels of governments (local, provincial, national).

- The sector is very labour intensive, with high mobility of the workforce and growing skills needs as construction technology becomes more sophisticated. The duration of contracts is often linked to the length of the site construction phase.

- Business relationships are temporary and often short-term, bringing together partners who may never work together again.

In fact, ICT usage in the construction sector is limited when compared with other industries such as manufacturing. While in part this may be due to the unique characteristics of the construction industry, there is a tendency for late take-up of ICT solutions, or when no appropriate solution exits, construction organisations develop closed proprietary solutions. Based on a wide industrial analysis and set of consultations, a set of current ICT usage trends were identified by Hannus et al. [1] as shown in figure 1.

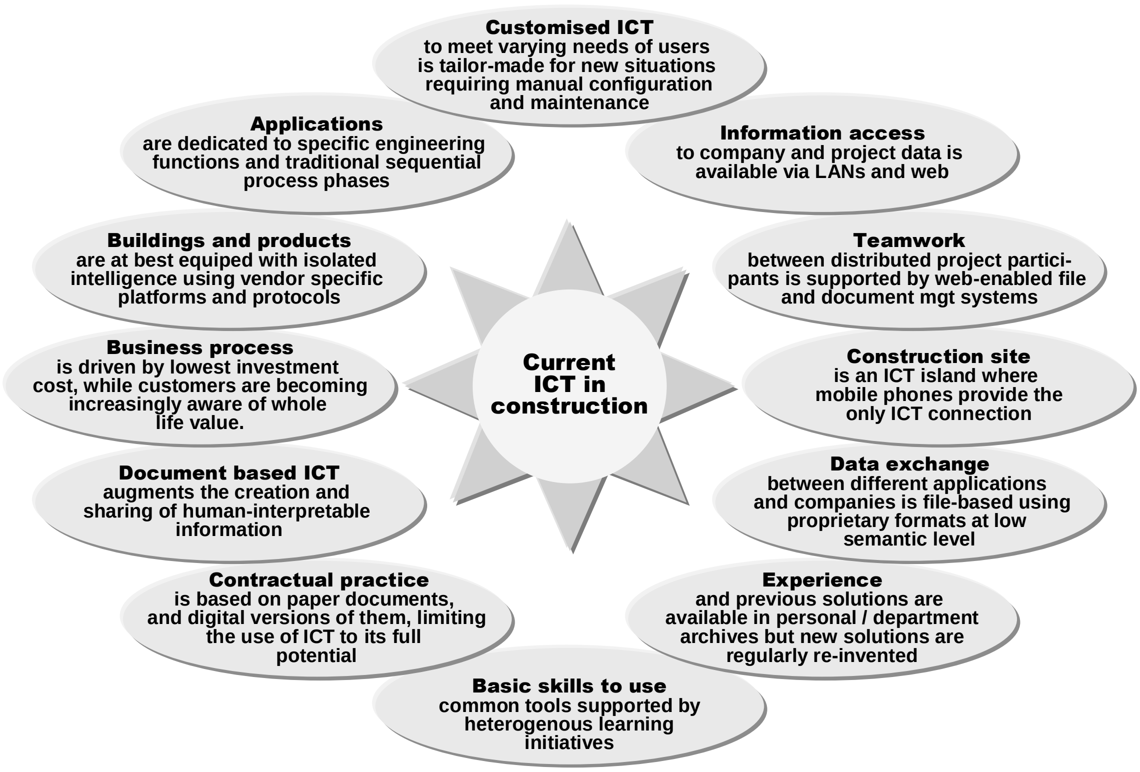

Figure 1: Current ICT Usage Trends [1]

Using the above trends (figure 1), as a baseline, a vision ICT in construction was defined as: *Construction sector is driven by total product life cycle performance and supported by knowledge-intensive and model based ICT enabling holistic support and decision making throughout the process by all stakeholders*. When compared with the current state (figure 1), it in essence promotes a paradigm shift from customised ICT to adaptive systems, from information access to ambient access, from teamwork to collaborative virtual teams, from construction site to digital site, from data exchange to flexible interoperability, from experience to knowledge sharing, from basic skills to ICT skills and awareness, from contractual practice to legal/contractual governance, from document based ICT to model based ICT, from business processes to performance driven processes, from buildings and products to smart buildings and products, and from applications to total life cycle support (figure 2).

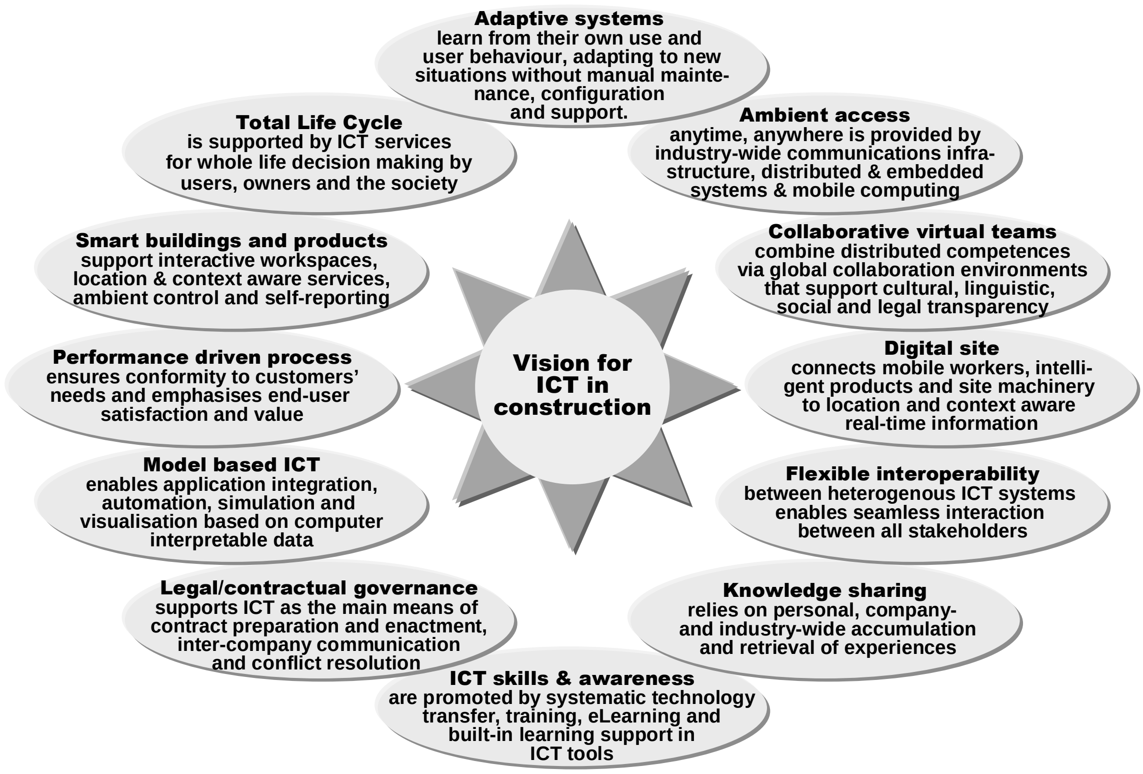

Figure 2: Vision for ICT in Construction [2]

One of the key steps in realising the transformation from the current state (figure 1) to the envisioned state (figure 2), is the mind shift in approach from data exchange and integration to interoperability. Efforts such as the nD modelling project [3] at the University of Salford, and the industry led initiative of the ProIT project [4] in Finland are major steps towards the realisation of the vision for ICT in construction and facilities management.

This book presents a global portfolio of ideas and perspectives in the development and use of ICT in construction and facilities management. The main coverage areas include ICT for design management, ICT in facilities management, the use of product models in construction, and the development and evaluation of ICT systems. While some cover research and development, others provide lessons learned from practice in the use of ICT for construction and facilities management. It is interesting to observe that all can to a certain extent be mapped on to one or more of the ovals (figure 2) contributing to the realisation of the vision for ICT in construction and facilities management.

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Section I

ICT for Design Management

ICT and the Architectural Design Process – Introduction of an ICT Impact Matrix

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Abstract

The essential topic of this paper is the impact of ICT on the architectural design process in the early planning stages. A fundamental pillar of a successful building project is a good design process. The use of ICT has over the years in different ways influenced and to a certain degree also changed roles and processes within the building project. An understanding of how ICT influences the complex mechanisms within the early stages of the planning process can be seen as central to achieve project success. The aim of this paper is to contribute to a better understanding and overview of the current situation regarding ICT related challenges and benefits within four essential aspects of the architectural design process. These aspects are: the generation of design solutions, the communication, the evaluation of design solutions and the decision-making. In the first section of the paper based on a literature review, some key elements from previous research in the area will be explored. Furthermore, an ICT impact matrix will be introduced, based on the four selected design process aspects and a definition of three hierarchical levels: the micro-, meso- and macro-level. The matrix outline suggests a way to organize the discussed design process topics on an overall level, and intends to contribute with a better overview of the ICT related impacts on the architectural design process.

Keywords: Architectural design process, ICT impact matrix, overview

1. Introduction

A fundamental pillar of a successful building project is a good design process. A primary idea emerges in a designer's head based on a complex iterative process between problem and solution. Taking into account different constraints set for the project the primary idea "materializes", eventually within a design team, into something that can become the conceptual fundament of the building project [1]. The future and development of a good architectural design solution depends on decisions made on several levels and by different actors. The architect will make his decisions about which design solutions are worth being put to the paper, and the client will be responsible for the crucial decision regarding which proposed concept should be developed further. The evaluation and decision-making due to a design solution depend among others of how it is communicated. The sender (e.g. the architect) of the information (e.g. the design solution) must encode the message in the form of some symbolic language, which is then transmitted, through a suitable medium (e.g. paper drawing scale 1:100), to the receiver (e.g. client) of the information. To access the design solution, the client must decode the message. Both the client and the architect decode and encode information based on their knowledge, or frame of reference [2]. Over the years, the ICT impact has lead to dramatic changes within the construction sector average working day. Both working processes and role definitions have been affected. The participants within the architectural design process face ICT related benefits and challenges at several levels. An understanding of how ICT impacts on the architectural design process and decision-making can be crucial for the overall success of the building project.

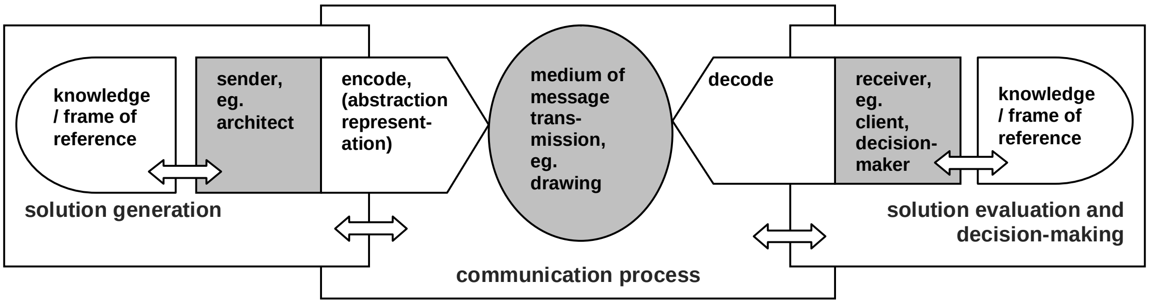

Figure 1: Illustration of the relations between the four selected architectural design aspects

The main topic of this paper is to contribute with a better overview and understanding of the today-situation of ICT related benefits and challenges due to four essential aspects of the design process: the generation of design solutions, the communication, the evaluation of design solutions and the decision-making. Figure 1 seeks to illustrate the relations between these four aspects, which are highly interdependent and iterative. The first part of the paper explores some key points, based on a literature review. This paper does not intend to give a complete picture of all ICT related impacts. Rather, the explored key points establish the background for the introduction of an ICT impact matrix, based on the four selected design process aspects and the definition of three hierarchical levels, the micro- (individual, e.g. architect), meso- (group, e.g. design team) and macro (overall/general, e.g. client)-level processes. The matrix outline suggests a way to organize the discussed design process topics, and could be one possibility to gain a better overview of the ICT related impacts on the different levels of the architectural design process. The introduction of the ICT impact matrix establishes the background for a theoretical framework and further research regarding the following issue: the ICT impact on building design management and decision-making – with focus on the architect’s role and contribution.

2. The Generation of Design Solutions

There has been a lot of effort to describe and explain the design process and the generation of design solutions since the early 1960s [3]. The first generation design methodologists focus on the design process as something sequential and linear, was to be challenged. Lawson [1] critically emphasizes that there is no clear distinction between problem and solution, analysis, syntheses or evaluation in the design process. The design process is a simultaneous learning about the nature of the problem and the range of the possible solutions. The design problem is difficult to define and reveal, is multi-dimensional and interactive. The challenge for the designer is to understand what really constitutes the problem, to recognize hierarchical relationships, to combine and to integrate [1]. The designer operates in a virtual world, a constructed representation of the real world in practice [4]. Abstract models or the media of communication (traditional: physical models, drawings etc.) allow the designer great manipulative and immediately investigative freedom without incurring time or costs, which would have been the fact if the ideas had to be tested directly at the building site [1]. However, the first generations aim to organize the design process in a rational and logical way, thus saving more time and resources for the intuitive and creative moments of the process [3], still have some relevance. One vehicle of achieving these early aims, although with other means, could be ICT.

2.1 Computer Aided Design or Drafting

The generation of design solutions is still perhaps the area, in which the ICT at least has gained a foothold [1]. For the moment, the CAD (Computer Aided Design) systems used within the design process, supports drafting and modeling rather than special design attributes and analytical capabilities and have not changed the task of drafting or modeling [2]. However, CAD systems have this far definitely brought benefits, such as the possibility of producing a huge amount of drawings in a limited amount of time, and the possibility of creating highly realistic and professional representations of the design solution. But can CAD support the generation of the design solution itself? Or is CAD rather what Lawson [1] calls Computer Aided Drafting? Designer skills such as intuition and the “feeling-of” are difficult to describe and map, and until now the computer has been unable to copy these parts of the human intelligence. In addition, the design process is still not fully understood; the human brain will for the next time probably remain the main media of the creative process.

2.2 ICT as Design Partner

However, there are parts of the solution generation process, in which the computer can support the generation of design solutions. The computer is able to handle enormous amounts of parameters, and combine them to alternative solutions, in much shorter time than the human being can. A research project at the ETH in Zürich, called “KaisersRot” [6], illustrates this. The computer generated solutions and alternative site patterns based on a huge amount of programmed parameters. The human brain would need substantial amounts of time in order to generate solutions matching all these parameters. The computer, however, could only generate sufficient solutions based on parameters recognized and programmed by humans.

Another research direction is the development of virtual reality (VR), which is based on geometrical and graphical representation. VR offers the possibility to navigate within and see the objects and their relation to each other in a 3D space. The possibility of a realistic imitation of a real world environment, combined with the spatial experience dimension, can become a powerful future design tool [5]. New experimental forms and constructions, without the real world constraints, can be realistically visualized. The possibilities of innovative form generation, can perhaps give the designer inspiration to develop an “evolutionary” architecture [1]. The success of such processes depends on how user friendly ICT is. Generally, the development of user-friendly interfaces of the ICT tools is a huge challenge. Thick user manuals and complicated operative surfaces can disturb the mediation of creative processes. Lundequist [5] compares this with driving a car: the driver should not be forced to concentrate on how to drive, but rather where to drive. However, Wikforss [5] compares the impact of the development of new computer media and graphical tools with the break-through of the central perspective in the renaissance. They both change our view of the world.

There is some effort to develop intelligent ICT systems that can carry out design operations on behalf of the human designer, so-called design agents [2]. A design agent can for example make a designer aware of inconsistency with building legislation, for example the minimum height of a staircase handrail. Thus, ICT would develop from being a tool to becoming a design partner. The development of design-agents is promising, but for the moment it seems impossible to replace the human brain completely as the generator of design solutions. ICT can be a tool or a partner supporting and relieving the designer, but the computer still cannot design without some sort of human interaction.

2.3 New Design Methods

The more intelligent ICT design systems could make it necessary to change the traditional methods of design. However, to make the designer change his working methods can be cumbersome. Kiviniemi [7] refers to Freeman's Attractor Theory describing an "energy landscape" in our brains; and he sees this as one reason why it is so difficult to implement new tools which influences the working methods (e.g. 3D product model), although such tools could offer obvious benefits.

3. Communication within the Design Process

The successful planning and realization of a building project depends heavily on the success of communication on many levels. Schön's [4] description of the designer's conversation with the drawing, or what Kalay [2] calls ideation or an intra-process role of communication represents one level. The dialogue between two individuals, the extra-process role of communication represents another. Failed communication can cause conflicts and misunderstandings, and negatively influence the building project, if not recognized and solved at an early stage. As illustrated in figure 1, the sending and receiving of a message (e.g. design solution) depends on the competence, knowledge and previous experiences of the participants in the communication process. If the client does not know the symbolic meaning, or the level of abstraction used, he will not understand what the architect tries to communicate, and this could lead to misunderstandings and conflicts. The architect can assume that the client knows which totality an abstraction represents, for example the plan drawing door symbol, but a problematic case of information loss could arise if the client does not know that the two lines on the paper actually symbolize a door. Generally, some of the knowledge playing a part within the design process is of tacit character. Explicit knowledge can be articulated and is thus accessible to others while tacit knowledge cannot be articulated [8]. Wittgenstein's language game theory is one illustration of this problem area [9]. Misunderstandings can occur when terms from one game are used within another. The language games are based on tacit rules embedded in the context, culture and way of life. Thus, such language games cannot be easily understood when viewed from another context or culture. A central part of the architect's competence is to understand the language games and to use terms in a meaningful way [9].

3.1 The Designer's Conversation with the Design Situation

Schön [4] describes the design practice (e.g. sketching) as a conversation or reflective dialogue between the designer and the design situation or design issue. This conversation is based on the designer`s "…capacity to see unfamiliar situations as familiar ones, and to do in the former as we have done in the latter, that enables us to bring our past experience to bear on the unique case." [4, p.140]. The designer conversation with the design situation allows a fluid thinking process without constraints like disturbing accuracy. The sketching act can mediate creative processes. Can ICT replace the scribbling with a pen at a sketch paper as mediator of creativity, without disturbing the fluid thinking process? Is the computer able to interpret sketches, which can often illustrate a variety of metaphors, and contain a high degree of uncertainty? According to Lawson [1], the answer is no.

3.2 Network Technologies and Collaboration

The importance of collaboration is growing, as globalization and increasingly complex technique and products require more teamwork, and the complexity of the problem becomes unmanageable for one individual. The focus changes from the individual to the collaborative design process, and introduces a new dimension in the idea finding process: the interaction between the individual and the group [1]. Participants with different backgrounds, preferences and experiences try to achieve a common goal. Barrow [10] introduces the term Cybernetic Architecture: "... cybernetic architecture is a return to the pre-Renaissance comprehensive integrative vision of architecture as design and building (…) the emerging architecture process is a "collective" body of knowledge and specialty skills found in many individuals."

Network technologies such as e-mail and the internet have contributed to the most radical changes within the average working day for the building process participants, for instance supporting processes independent of geographical and organizational borders. Collaborative design and communication within a virtual instead of collocated situation inherits many new properties, and this eventually leads to various challenges. The network technologies still offer neither the same social presence and information richness, nor the ability to transfer tacit knowledge that a face-to-face collaboration or conversation does [11]. Herein lies a challenge; to develop network technologies offering the communication possibilities necessary for the achievement of a common understanding, to solve complex problems or to generate complex design solutions. Within the communication process between two or more individuals, ICT have had a dramatic impact on the medium of communication. This could possibly require another use of language and level of abstraction and challenge the skills of the message receiver, hence to another culture of communication.

3.3 Information Access and Distribution

The network technologies make an easy and fast access to and distribution of information possible. This has been a huge benefit within the building project and has, according to Schwägerl [12], contributed more to accelerate the design processes than the CAD tools. The development of the data based technologies, server or internet-based, has been an important support of handling the huge amount of documents and drawings within building project. The pool of material is accessible to the different projects participants, anytime. The participants have to actively retrieve the information they need, and this is different from the traditionally passive "getting-the-plan-with-mail"; there is a development from a push to pull of information. The use of databases, network technologies etc. supports the distribution speed of information required to keep the project continuously running. However, much of the information could be considered more of a distraction than actually useful, given a specific situation. The negative effect of information overload is growing. Thus, the attention of the receiver is becoming an important resource [13].

3.4 Communication Standards and 3D Product Models

Another influential trend within ICT is the development of communication format standards between different programs and systems, ensuring interoperability. An example of such a standard is the Industry Foundation Classes (IFC) [5,7]. The development of communication standards is one of the fundaments for a research field by many seen as one of the most promising within the construction sector: the development of the 3D product model or building information model (BIM). Such models are based on the definition of objects (products) containing intelligent information. The main objects, such as doors and windows, are standardized. According to Fekete [14], such standardisation could become barriers within the creative process; design elements that fall outside the standardized repertoire of building objects could be difficult to generate without special ICT skills. However, every participant (design team, legislators, contractors, manufacturers etc.) in the building process can get access to, make contributions to or receive information from this model in parallel. All building project information is gathered in this one model, and there are no parallel illustrations of building parts comprised of plan, section, detail etc. This can reduce one of the main sources of building site failures: inconsistency within the fragmented drawing and document material [5,7]. From the model "traditional" drawings can easily be generated, and the density of information can be controlled.

3.5 Redefinition of Planning Stages, Roles and Responsibility

Through the use of ICT, processes can be accelerated and traditional stages can overlap. Already at a very early stage of the design process, traditionally later participants can get access to e.g. the 3D product model. Contractors, specialists and manufacturer can contribute with knowledge that helps to reduce uncertainty early in the design process. The "wheel of dominance" [15], illustrating which participants dominating the different planning stages of the design process, could change. But the overlap between earlier and later planning stages can perhaps contribute with constraints that increase the complexity of the solution and problem finding, making it more difficult to focus on the right aspects to the right time. The Figure “Island of Automation in Constructions” [16] illustrates the current construction sector as many separate islands in a big construction sector ocean. The ICT, in this case the product model, leads to a “land raising”, the many small islands transform to one big island. Thus, the traditional boarders between roles or planning stages blur and change. The separate bits of the planning process are melting and compressed to a conglomerate. The ICT development changes the human perception of distance and time. The understanding of these different changes is central. ICT impacts on the definition of work processes, roles and responsibility. How can such changes be handled within contract and procurement models? What about the traditional role and contribution of the architect?

4. Evaluation of Design Solutions

The architectural design process is in addition to the measurable, quantitative and conscious based on the qualitative, intuitive and tacit [1,7]. The crucial question within evaluation of design solutions is how to measure or judge the qualitative, tacit and intuitive aspects? “Is it possible to say that one design is better than another and, if so, by how much?”[1, p.62]. This aspect is also challenging within the other three aspects of the design process: the generation of design solutions, the communication and the decision-making. Lawson [1] emphasizes that a crucial skill of the designer is to balance qualitative and quantitative aspects.

4.1 “Almost Real”

ICT Offers A Most Powerful Support Of Evaluation. Through Simulation And Highly Realistic Visualizations It Is Possible To Get An Impression Of The Real-World Building Project Before It Is Finished. Unrecognized Problems Can Be Identified, Uncertainty Reduced And Errors Avoided Already At An Early Stage Of The Building Project. In The Management Area ICT Support Time-, Cost- And Resource Planning, In The Design Process They Simulate For Example The Financial And Climatic Effects Of The Ventilation-And Heating System. Presentation Tools Supporting VR, 3D-Modeling, Animations Etc. Can Support The Evaluation Of Visual Qualities [5]. However, A Conceptual Image Communicated In A Highly Realistic Manner Can Also Give A False Picture Of The Reality. There Can Be A Conscious Or Unconscious Mismatch Between The Intention Of The Sender And The Interpretation Of The Receiver [1].

These Tools Usually Require The Presence Of Something To Evaluate, And Also That Some Level Of Precision Has Already Been Reached. And Such A Level Is Often Not Feasible In The Early Design Stage. Lawson [1] Characterizes The Too Early Precision Temptation As The Design Trap Of Over-Precision, Which Can Become A Creative Process Impediment. Until Now, The Building Of ICT Models As Foundation For Simulations Has Been Cumbersome And Expensive. This Often Resulted In Simulation Of Limited Parts Of The Total Design. But The Design Problem Is Multi-Dimensional And Interactive. Interconnectedness Of Different Factors Is An Important Issue. The Focus Only On Parts Can Lead To A Lack Of Integration, Thereby Reducing The Quality Of The Project In Total [1]. The Possibility Of Importing 3D Product Models Into Simulation Software Reduces The Model Building Effort And Thus The Building Could Be Simulated And Tested In Total [7].

4.2 Information Overload

We do not now much about how the human being handles and edits information [5]. The ability to absorb information is limited, and when confronted with too much information, the receiver can lose the overview, or worse, completely ignore the message communicated; thus leading to crucial information being lost and unrecognized. An information overload could possibly result in a loss of focus on the important aspects within evaluation and decision-making. Valuable time must sometimes be spent filtering relevant from unimportant information. Some ICT development projects try to establish methods for the filtering of internet-based information [5]. Generally, who decide the filtering criteria by information distribution and exchange? How do we know that important, but perhaps not obvious, information actually passes such filters?

5. Decision-making

Faster information distribution, better access to information and more powerful communication tools contribute to an acceleration of the planning process, making a higher decision frequency possible [17]. An important skill of the designer is to juggle with several ideas at the same time, without forcing a premature precision or decision [1]. Does the use of ICT force too early decisions and generate artificial constraints? Is there a limit of time compression within the architectural design process and decision-making? Also Wikforss [5] emphasizes the importance of enough time for maturing in the planning- and decision process, and that there is enough time to reflect and understand the consequences of different solutions and decisions. He emphasizes that ICT tools, e.g. the 3D product model, must allow a step-by-step precision.

Seemingly, it is easier to make a decision if every uncertainty is eliminated. ICT offers the possibility of storing and capturing previous project experiences, as well as reusing and modifying these experiences from previous building projects within new ones. This is an often-used method to reduce the high degree of uncertainty in the early design phases, and to better support the estimate of cost and time factors before the concept has reached the required level of precision. Lundequist [5] sees a possible conflict between the established experience and the will to innovation. The knowledge reservoir is based on tested experiences, repertoires and routines. The inherent capabilities of ICT when it comes to knowledge storage and reuse could lead to a misbalance between previous knowledge and innovation in the creative process.

ICT offers the possibility to simulate and visualize the building in a nearly realistic way, to make information available whenever wanted and to make processes transparent and “reusable”. However, the nature of the design process is also qualitative, subjective and highly uncertain. As “the feeling of” is a part of the design process, intuition and the acceptance of risks are also part of the decision process. According to Griffith [8] ICT supports the declarative nature of explicit knowledge. Possibly the analytic, quantitative and explicit nature of the computer could disturb the balance between the qualitative and quantitative, tacit and explicit, intuitive and conscious. This could potentially lead to a bias within evaluation and decision-making, having negative effects on the total building quality.

6. Introduction of the ICT Impact Matrix

This paper presents a broad range of different ICT related impacts within the architectural design process and decision-making and focuses on four main topics, the generation of design solutions, the communication, the evaluation of design solutions and the decision-making. The main intention of the paper is to be a contribution towards a better understanding and overview of the ICT impact on the selected architectural design process issues. The overview, an ICT impact matrix, is based on the definition of three hierarchical levels:

- **The micro-level:** focuses on the individual and what is going on in the head of the designer, in this case the architect. The designer's conversation with the design situation is an example of micro-level communication. Example decision-making: which idea is worth being put to the paper etc.

- **The meso-level:** covers the mechanisms within the group, in this case the design team. Design management. Collaborative design generation and evaluation. Example decision-making: which concept should be presented etc.

- **The macro-level:** comprises the mechanisms on overall project level, including all participants, such as stakeholders, manufacturer etc. Project management. Example decision-making: which concept should be further developed and realized.

Within each of these levels, the ICT related benefits and challenges due to the four illustrated and described aspects of the design process are summarized. The introduced matrix is not intended to force aspects of the complex architectural design process into rigid categories, rather it could be a help in acquiring an overview and understanding of the complexity within the design of an building project.

Table 1:Outline of the ICT impact matrix

	Micro-level	**Meso-level**	**Macro-level**
Generation of the design solution Examples ICT: CAD, VR, sketching programs, design-agents etc.	**Benefits:** • Development from design tool to design partner. • Handling and combining of amounts of parameters and constraints in short time. • Advanced visualization of design idea possible. **Challenges:** • Computer systems requiring too much precision • Complicated user surfaces can disturb the mediation of creative processes. • ICT should support step-by-step precision.	**Benefits:** • Supporting the development of collaborative design. • Advanced visualization of design idea possible. **Challenges:** • Interaction between individual and group design generation – "cybernetic architecture ".	**Benefits:** • Advanced visualization tools as VR a possible trigger of innovation and "evolutionary" architecture. **Challenges:** • Computer as design solution generator without human interaction until now not possible. • Standardization of design elements leading to creativity barriers? • New methods of designing - difficulty of adapting new ways of work.
Communication within the design process Examples ICT: 3D product models, databases, network technologies (e.g. Internet, e-mail, WorldWideWeb) etc.	**Benefits:** • Better access to information for the individual. **Challenges:** • To replace the power of pen and paper as the media between the designer and the design solution generation. • How to transfer tacit knowledge with ICT?	**Benefits:** • Support geographically dispersed collaboration. • Less inconsistency of project material. • Interoperability within design team • Better access to and distribution of information within design team - speeding up of communication process **Challenges:** • Less social presence and info richness as F2F can lead to misunderstandings and conflicts. • Different knowledge reservoirs within design team–source of conflicts. • From push to pull of information.	**Benefits:** • Better access to and distribution of information within building project. • Interoperability on overall level. • "Land-raising" within construction sector – more transparency – better foundation of collaboration. **Challenges:** • Redefinition of roles, responsibility and planning stages • Misunderstandings due to represented decision material (intention not like intepretation). • New communication and collaboration culture.
Evaluation of the design solution Examples ICT: 3D product models, simulation tools (e.g. cost, time, climatic aspects), 4D models etc.	**Benefits:** • Almost real world simulation and visualization, early recognition of conflicts and problems. **Challenges:** • Information overload – loss of overview and focus for the important.	**Benefits:** • Almost real world simulation and visualization support coordination within design team – early recognition of conflicts and problems. **Challenges:** • Simulation or visualization of only building parts – loss of overview and total quality. • Information overload and loss of focus and overview.	**Benefits:** • More transparency of processes and better access to knowledge, not individual captured. • Almost real world simulation and visualization, early recognition of conflicts and problems. **Challenges:** • How to judge and measure the quality of a design solution? • Information overload and loss of focus and overview.
Decision-making within the design process Examples ICT: 3D product models, simulation tools (e.g. cost, time, climatic aspects), 4D models, VR, 3D modeling tools, network technologies etc.	**Benefits:** • Decision material more consistent and real-world like – reduction of uncertainty **Challenges:** • Realistic visualization and simulation forces too early decision? Obstruction of the creative processes and parallel lines of thought?	**Benefits:** • Decision material more consistent and real-world like – reduction of uncertainty **Challenges:** • Realistic visualization and simulation forces too early decision within design team?	**Benefits:** • Decision material more consistent and real-world like – reduction of uncertainty • Reuse of previous experience easier -reducing uncertainty. **Challenges:** • Misbalance between use of previous project material and innovation? • Forces too early decision not representative for the factual status of project? • ICT focus on quantitative - bias in the decision-making?

7. Conclusion

The introduction of the ICT impact matrix illustrates a possible way to approach the wide range of ICT impacts on the complex field of the architectural design process. The processes within architectural design and decision-making can perhaps be compared with the nature of the design problem itself: as multi-dimensional and interactive, based on an interconnectedness of different factors. On one hand, the four selected design process aspects: the design solution generation, the communication, the design solution evaluation and the decision-making are highly interdependent, as the figure 1 in the introduction part attempts to illustrate. On the other hand, the defined micro-, meso- and macro-level levels are closely interconnected. These issues constitute the challenge and main problem area behind the theoretical ICT impact matrix. In a next step the matrix could be discussed and tested using e.g. real life projects. It could also be interesting to study the interaction between different levels, such as the relation between the architect and the design team, or between the architect and the client. Further inquiry could lead to a modification of the ICT impact matrix, the three level approach and the choice of design process aspects. Generally, the matrix outline could be developed into a filter for deciding the direction and focus of further work and research. From the view of an architect, a crucial question is how the ICT related benefits and challenges impact his role, influence and contribution within the architectural design process and decision-making.

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Cost Management and Estimates in the Infrastructure Design Process

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Abstract

The infrastructure client must know the relation between the variant decisions and the cost already in the beginning of the design process. That is the only way the client can influence on the important decisions made during the design process so that there is real influence on the final cost level.

The Laboratory of Construction Economics and Management in Helsinki University of Technology and Rapal Ltd work tightly together in order to create new methods and databases for cost management of infrastructure projects. There are two different studies going on at the moment.

The one is focusing on the client´s target setting process in planning before the actual design process. The aim of the study is to develop a method and tools for defining a project and it´s targets so, that the client´s needs and will can be clearly expressed. The other one is considering to the cost management during the design process. How the real cost level is estimated in every step of the process? And how the design alternatives are compared? These two studies are introduced in this paper.

The first step in the infrastructure management is to define the project. The definition documents produced, a project plan, form the target for designing. It is a description of the scope of the project. Project plan must not unnecessarily limit the technical solutions made in the following designing phase. During the designing phase the document is updated if necessary.

The cost management of the infrastructure starts from the scope definition of the project. The client defines the needs and the targets of the project. The first cost estimate is based on the costs of the reference projects. The targets and the needs are modelled with the end product elements, which consist of the building element based product model. The end product elements are big functional elements of the infrastructure, for example main route, intersections, lightning system, water management system. The product model gives the target cost of the project.

The product model based target cost gets more accurate when the design process goes on and the product model is changing to the real measured building elements. The price of building element is estimated based on the way the work is done usually in that kind of circumstances. The typical work processes are documented to the cost storage.

In the first study the project plan –document is created and tested for the needs of infrastructure projects. In the second study the cost estimate procedures (the end product element and building element systems) are created and tested. The both testing processes are made in the collaboration with the real infrastructure projects given by the clients of Rapal Ltd, the 10 biggest infrastructure clients in Finland (8 big cities, the Road Administration and the Rail Administration).

The studies are still going on. The project plan is tested and the first results indicate that the systematic scope definition with the project plan clear out the needs of the project more accurate than usually in infrastructure projects. The first results also indicate that the first end product element based estimate, the building element based estimate and the real market price can be inside the 5-10 % marginal. The new method is more accurate than traditionally used experimental methods.

Keywords: Infrastructure, design process, cost management, end product element, building element, project plan, product model

1. The New Infrastructure Design Process

1.1 Overview

Ten big infrastructure clients (property owner organisations) in Finland (National Highway Administration, National Railroad Administration, Cities of Helsinki, Espoo, Vantaa, Turku, Tampere, Kuopio, Oulu and Jyväskylä) and commercial private owned company Rapal Ltd have made an agreement for the cost management development project lasting 6 years (2003-2008). The target of the project is:

- To create a common used and tested infrastructure cost management system
- To create new consulting markets for construction economics in the infrastructure branch

The 10 client organisations made a consortium agreement with each other. The consortium and Rapal Ltd made a partnership agreement for the project. The systematic development project includes:

- The project plan – the systematic scope definition method
- The cost management systems

    - End product element based cost management system for the scope prizing
    - Building element based cost management system for the design solution prizing
- The systematic cost management database
- The economic trend description system

The target of the project is in year 2008 when all the methods cover the whole product life cycle of infrastructure. There are two specific studies going on related to the project. The first one is related to the project plan and the other one is related to the cost management process. The systematic cost management database and the economic trend system relate to the studies strictly.

1.2 Process Relevance

Nowadays the scope definition, the cost management systems and information databases are organisation related with no common rules. The mean of this project is to organise and to find out the best practise process of the infrastructure cost management in Finland.

The difference between the reasons of the infrastructure project cost is related to three categories:

- The scope
- The design solutions
- The economical situation on the market

The infrastructure (highways, streets, railways and big industry yards) investment and maintenance cost in Finland for example were worth of 1,8 billion euros year 2002. The relevance to the whole society is huge when cost management information is handled in one common and systematic way based on the cost classification (fig1).

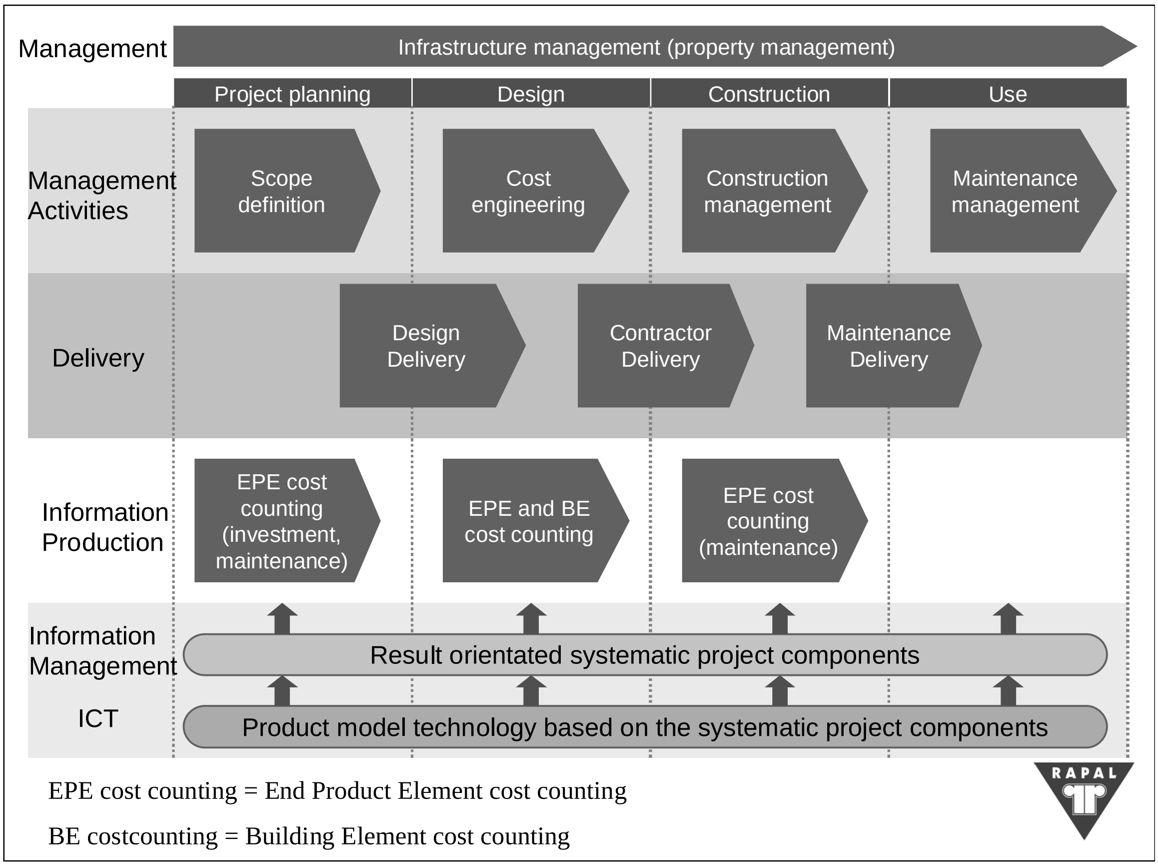

Figure 1 The process of the systematic infrastructure property management system

2. The Scope Management Process

2.1 The Systematic Scope Definition

The infrastructure projects are usually long term projects with lots of interest groups. The better the scope is defined the better the cost management is able to be done. In the development project Rapal has developed a systematic scope definition which includes:

- Project Plan – a document for the infrastructure scope definition
- List of end product elements - Systematic project component list

The project plan is a document which describes the result (the scope) of the project divided to the end product elements. Each element is based on the specific need (fig1) and is systematically described for the starting information of the design process.

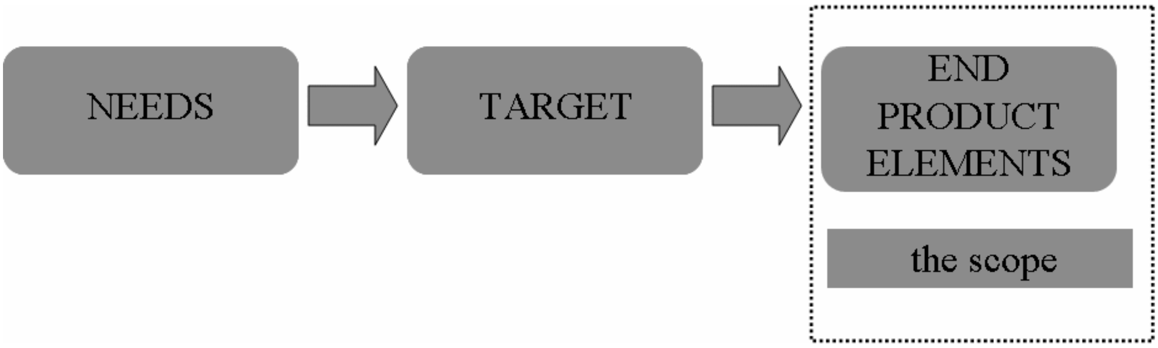

Figure 2: The needs of the project are changed to the targets, which are described as end product elements with the scope.

The end product element list includes the following subtitles:

- Routes for the motor engines
  - Highways
  - Streets
  - Railroads
- Tunnels
- Bridges
- The light traffic routes
- Other routes
- Parks and green areas
- Squares and market places
- Waste management
- Rock facilities
- Traffic areas
- Systems related to infrastructure

The project plan and the systematic project component definition have two major meanings:

- To describe the project
- To create the drivers of the project management

The scope of the end product element includes lots of sub targets (cost, quality, schedule). The cost management is the only one considered in this paper.

2.2 Cost Management by the End Product Element System

The scope defined in the project plan can be executed in many different ways. There are lots of combinations of design, cost, quality and schedule for example. The end product element based cost management system provides a price, which is typical solution of the kind of end product.

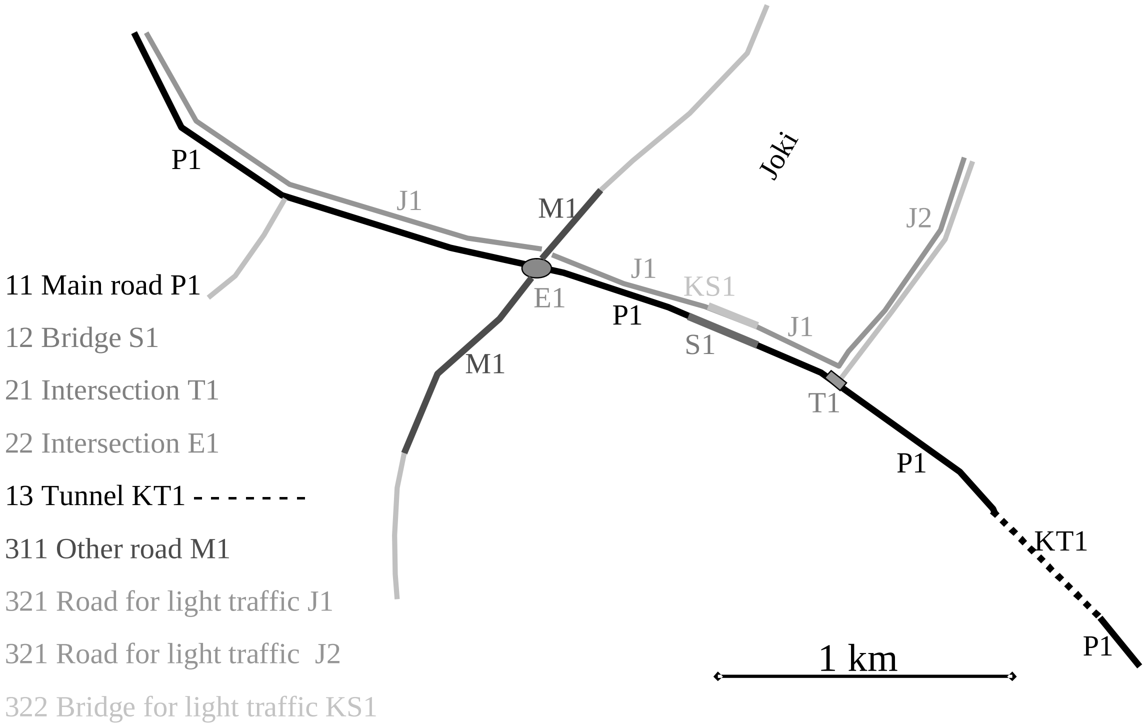

Figure 3Example of the end product element division

The cost management process by the end product elements has the certain steps:

- To identify the components of the project
- To identify the end product elements of the project components
- To get price for each end product element from the price list (fig 4)
- To identify the additional circumstances (for example environmental, interference caused by the built environment)
- To identify other additional costs
- To define the costs related to the project management (for example the difference between big and small projects)

The end product element price of the project depends on the made project plan. If all the big components are taken into account, the additional costs are identified and the desired cost allocations are made the projects scope can be estimated strictly in a very early step of the project. The rest of the project is all about project management.

PRICE LIST FOR TYPICAL END PRODUCT ELEMENTS										
100 ROUTES FOR THE MOTOR ENGINES										
			unit	basic prize	additional cost					
110	ROUTES	FUNCTIONAL FEATURE		A frost resistant ground	rock ground	frost exists	soft ground h = 2m	soft ground h=x (3-5m)	soft ground h=x (over 5m)	needs rock extracting.(h=x)
	111 Highway 4 lanes: 2 x (11,75m/7,5m)	100-120 km/h KVL 9000-30000	m	1180	+270	+230	+710	+650x	+600x	+230
	112 Highway 4 lanes: 2 x (10,25m/7m)	80 km/h KVL 9000-30000	m	1070	+250	+200	+630	+600x	+550x	+200
	113 Main road 2 lanes: 13m/7,5m	100 km/h KVL 6000-9000	m	600	+150	+120	+400	+250x	+300x	+135
	114 Main road 2 lanes: 10,5m/7,5m	100 km/h KVL 3000-6000	m	525	+130	+100	+330	+200x	+230x	+110
	115 Main road 2 lanes: 10m/7 m	60-80 km/h KVL 3000-6000	m	505	+120	+95	+290	+180x	+200x	+105
	116 Local road 4 lanes: 17,5m/14,5m	50-70 km/h KVL 9000-30000	m	900	+200	+160	+500	+500x	+460x	+185
	117 Local road 2 lanes: 8m/7m	70-80 km/h KVL 1500-3000	m	340	+80	+90	+260	+600	+600	+80
	118 Local road 2 lanes: 7m/6m	50-70 km/h KVL 600-1500	m	270	+65	+75	+230	+400	+400	+70
	119 Local road 2 lanes: 7m/7m	80 km/h KVL 100-600	m	260	+60	+70	+230	+300	+300	+70
	120 Local road 2 lanes: 6m/6m	70 km/h KVL 100-600	m	210	+50	+60	+190	+250	+250	+60
	121 Local road 1 lane: 5,5m/5,5m	40-60 km/h KVL 100-600	m	165	+40	+50	+170	+230	+230	+50

Figure 4 Example of the end product element price list

3. The Cost Engineering Process

3.1 The Cost Management by the Building Element System

The cost management by the standard building elements gives the answer for the question: "What is the price of the certain design solution?" The standard building elements consist of the recourse model, which is updated by the market related resource prices.

The building element system has three purposes:

- With the building element price the design result can be compared to the scope (the end product element price)
- It gives comparable prices for different design solutions
- It gives the market price estimate for the contract

The systematically used building element method requires that:

- Many separate nomenclature items are used
- Price lists are tested with the real executed contracts
- Pricelists are maintained (from the resources)
- The price list items and the used design items are comparative

BUILDING ELEMENT ESTIMATE, INFRASTRUCTURE
Version 0.91

Project name

Region 100,0

Basic cost level = 100,0
Cost level = 100,0

RAPAL

Date

BE	BE2	BUILDING ELEMENT	UNIT	QUANTITY	PRICE €	MULTIPLY	COST €
1000	**000**	**Maa- pohja- ja kalliorakenteet**		1		1,00	0
						1,00	
1100	**000**	**Purettavat rakenteet ja rakennusosat** 1				1,00	
1110	000	Luonnontilainen maa ja kallio				1,00	
1110	001	Luonnontilaan muutettu/jätetty alue	erä			1,00	
1120	000	Puut- ja kasvillisuus				1,00	
1120	100	Puiden ja kasvillisuuden poisto				1,00	
1120	110	Hyötypuun hakkuu pienet määrät (alle 10 kpl)	kpl		40,00	1,00	
1120	111	Hyötypuun hakkuu keski määrät (11-100 kpl)	kpl		25,00	1,00	
1120	112	Hyötypuun hakkuu suuret määrät (yli 100 kpl)	kpl		12,00	1,00	
1120	113	Jätepuun ja kasvillisuuden poisto, normaali	m2		0,68	1,00	
1120	114	Jätepuun ja kasvillisuuden poisto, tiheä puusto	m2		1,20	1,00	
1120	115	Jätepuun ja kasvillisuuden poisto, harva puusto	m2		0,30	1,00	
1120	116	Hyötypuun hakkuu	m3		5,58	1,00	
1120	117	Latu-uran raivaus ja tasoitus	m2		1,50	1,00	

Figure 5Example of the building element price list

3.2 The Cost Information Storage

The systematic cost management needs the systematic information storage. The end product elements have certain requirements for use, investment, environment and functionality. Those requirements can be modelled through the certain steps:

- the product elements (for example foundations, surface layers)
- the building elements (for example earth excavation, insulating layer, asphalt layer)
- The production elements (for example mass transportation, vibrations)
- And the resources (for example excavator, asphalt)

The modelling system needs a structured nomenclature for every step of the tree. Nomenclature gives every piece of data a certain individualized code number, which keeps the system in order.

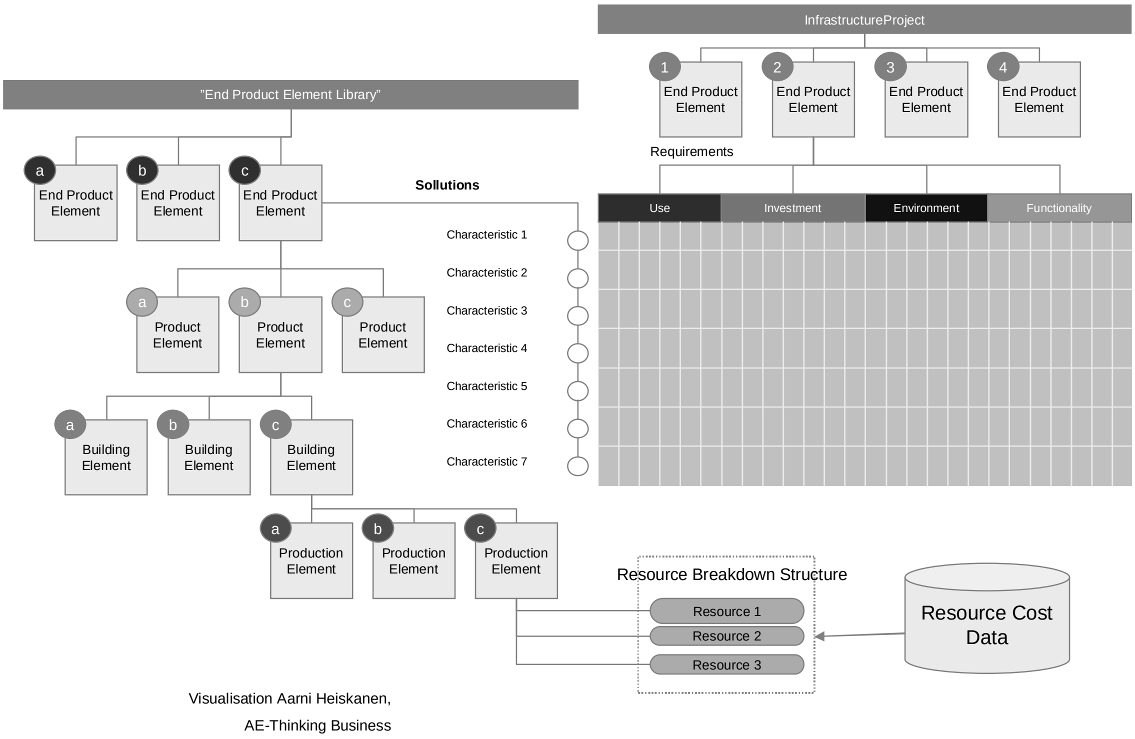

Figure 6 The systematic cost management information storage

The cost management system is built up to the database. The database has the strict structure to keep all the information in order. The Rapal Cost Management system is planned to follow the Finnish common Infra-nomenclature, which is developed by Rakennustieto and Helsinki University of Technology. The product model work is just starting in Finland, but in the basis of today´s information the product model and the end product elements have the same kind of main structure.

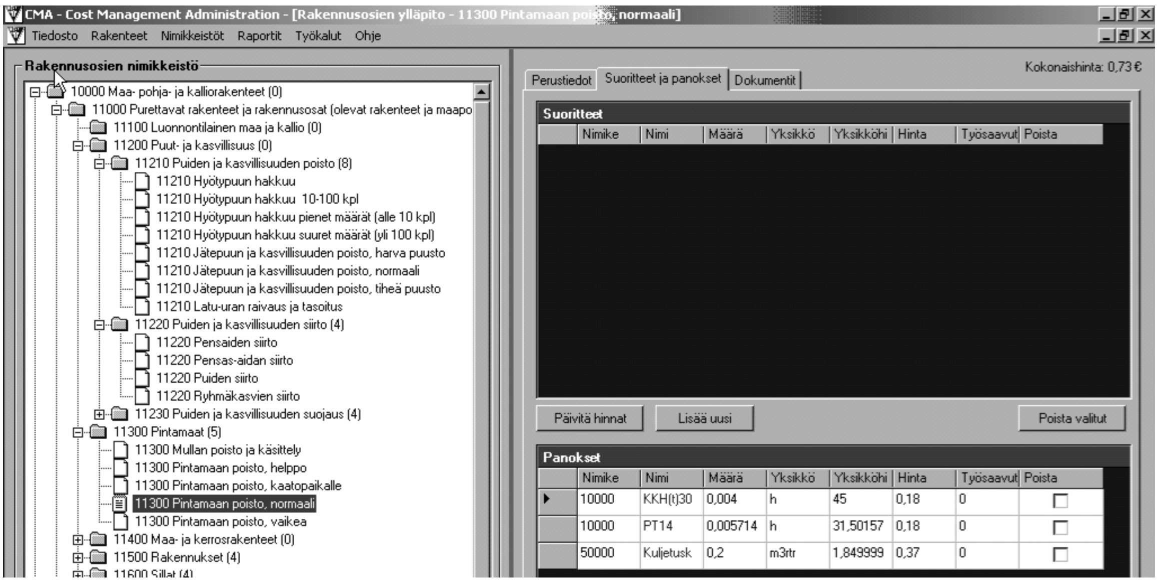

Figure 7 Example of the cost database

4. The Benefits of Process

The benefits of the systematic cost management system are:

- The real needs of the project are identified earlier with the project plan method and the update of the project plan during the process is easier because of the systematic description method

- The cost level of the project can be modelled earlier and more exact than before because of the defined scope

- The cost level in every step of the project is comparative because of the structured product elements

- There are comparative prices in different projects because of the common cost management system

- The feedback of the prices in the executed contracts is straight in the use of the system

5. Conclusions

The infrastructure cost management is said to be difficult because of so many various variables (natural environment, different ground, built environment). In this project Rapal has studied and investigated over 100 real infrastructure cases during 2003-04. The system development is still going on and more information especially about the maintenance is on the scope of the project.

Conclusion of the results so far is that:

- The systematic scope management before the design process is the key to the good cost management

- To get the good cost estimate in the early stage of the project we need new kind of requirement based end product element system

- The building element system needs systematic information storage and continuous systematic feedback from the real projects to remain valid and updated

- The common cost management system gives benefits of synergy to all the organisations

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A Case Study of Project Document Management in Building Design

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Abstract

The problem of managing all the information in building design is a real challenge. Electronic Document Management is growing rapidly and generates the need to structure of design information across building design companies. Lithuanian standardisation organisations, professional associations, user groups, individual companies don't have unified rules of CAD standards and guidelines in building design industry. The most important issue in efficient IT application is the standardized reference of all data definitions.

Keywords: Computer aided design, electronic document management, product data management, building information technology.

1. Introduction

In today's fast-paced economy, building design companies with multiple enterprises such as architecture, engineering and construction (AEC) are seeking for new efficient ways to streamline their business processes, so that the project development time and costs can be reduced. Project development time is typically long due to a considerable volume of documents that required to be transferred between the members of different project teams. Another possible reason for high project development time and costs is that even typical projects have to be developed from the bases, since there is no centrally and easy accessible information storage. It is based on well-know fact that designers spend 75% of their time searching for the appropriate documents, and only 25 % of the time actually modifying it [1].

As an efficient solution the mentioned above problems is the application of the product data management (PDM) systems, that facilitate the management of documents pertinent to particular enterprises, projects and work groups in computer networks. In addition to the basic file management capabilities, PDM systems contain enhanced features related to the life-cycle, revision history and version management of particular classes of documents [2]. A number of commercial tools have been created for document management, project information sharing, online communication, design workflow, construction workflow, time control, and securing information [3]. The case study presented in this work demonstrates how PDM system has become an important element in keeping control of company design activities. It served as a central repository for design information, and digital data documenting the progress.

2. Generic Model of Digital Design Data Archive

A growth of the work intensity in building design companies creates the difficulties of management information flows in the projects. In fact, project management can be accomplished as document life cycle control. The successful application of PDM systems strongly depends on the appropriate structure of the central archive for design information. Preserving information in digital forms is much more difficult than preserving information in forms such as paper. This is not only a problem for traditional archives, but also for many organizations that have never thought of themselves as performing an archival function. The workflow presented for the archive of the construction design documentation is based on ISO Reference Model for an Open Archival Information System (OAIS) for a data repository system [4, 5, 6] (Figure 1). The role provided by each of the entities in OAIS can be described briefly as follows:

- **Ingest**: This entity provides the services and functions to accept Submission Information Packages (SIPs) from Producers (or from internal elements under Administration control) and prepare the contents for storage and management within the archive.
- **Archival Storage:** This entity provides the services and functions for the storage, maintenance and retrieval of Archival Information Packages (AIP).
- **Data Management:** This entity provides the services and functions for populating, maintaining, and accessing both Descriptive Information which identifies and documents archive holdings and administrative data used to manage the archive.
- **Administration:** This entity provides the services and functions for the overall operation of the archive system.
- **Preservation Planning**: This entity provides the services and functions for monitoring the environment of the archive and providing recommendations to ensure that the information stored in the archive remains accessible to the designated user community over the long term, even if the original computing environment becomes obsolete.
- **Access:** This entity provides the services and functions that support consumers in determining the existence, description, location and availability of information stored in the archive, and allowing consumers to request and receive information products.

For the definition of information handled by OAIS the paradigm of the information object is applied. Every submission of information to an OAIS by a Producer, and every dissemination of information to a Consumer, occurs as one or more discrete transmissions. Therefore, it is convenient to define the concept of an Information Package. Three different types of the packages are implemented:

- Submission Information Package (SIP);
- Archival Information Package (AIP);
- Dissemination Information Package (DIP).

Within the OAIS one or more SIPs are transformed into one or more Archival Information Packages (AIP) for preservation. The AIP has a complete set of Preservation Description Information (PDI) for the associated Content Information. In response to a request, the OAIS provides all or a part of an AIP to a Consumer in the form of a Dissemination Information Package (DIP). The DIP may also include collections of AIPs, and it may or may not have complete PDI. The Packaging Information will necessarily be present in some form so that the Consumer can clearly distinguish the information that was requested.

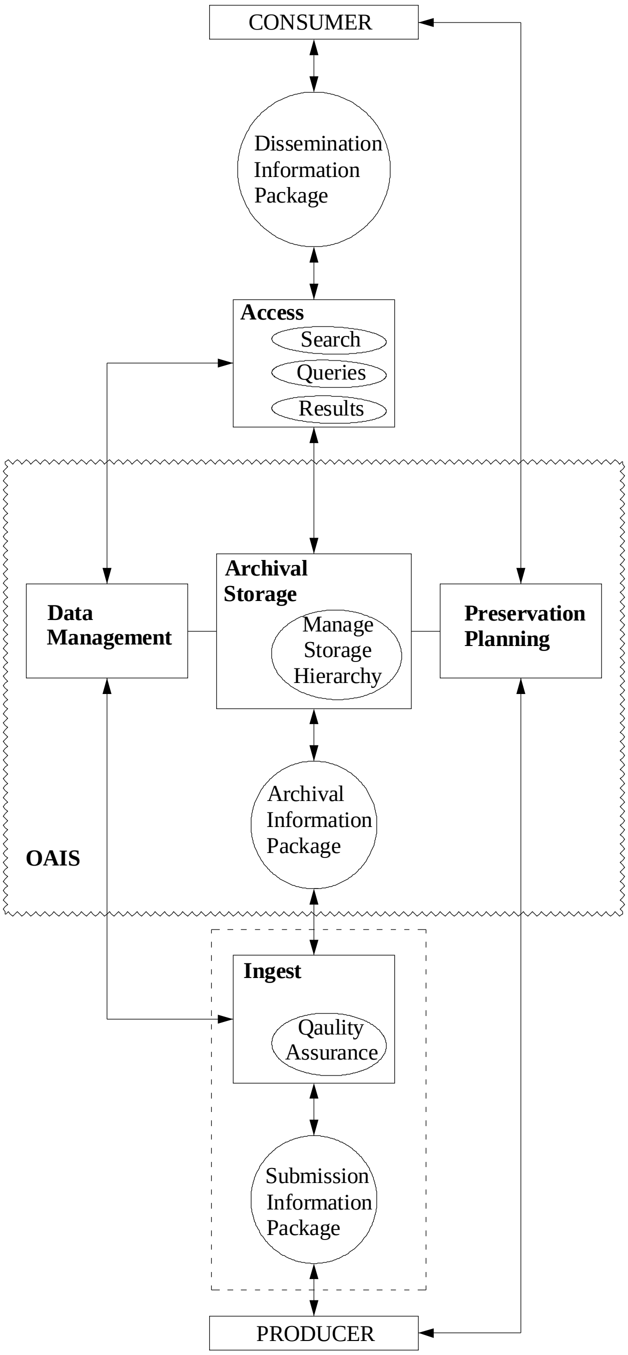

Figure 1: Archival information system

3. Framework for Archiving Digital Design Documentation

The structure of the digital design documentation archive have to be tailored towards the specific needs of the design company and requirements of the construction regulatory laws [7]. For the design management of the building, most documents and communication were exchanged electronically and reflect in a way the name of the project. The developed PDM system stores all documents and communications related to a project in a document repository that facilitates keeping track of those documents throughout the duration of a project and later on. The archive is meant to store in a structured way all kinds of documents and communications to clients, consultants, suppliers and subcontractors. Due the project-centric nature of the construction industry the structure of archiving of the design documents reflects the main parts of the project (Figure 2).

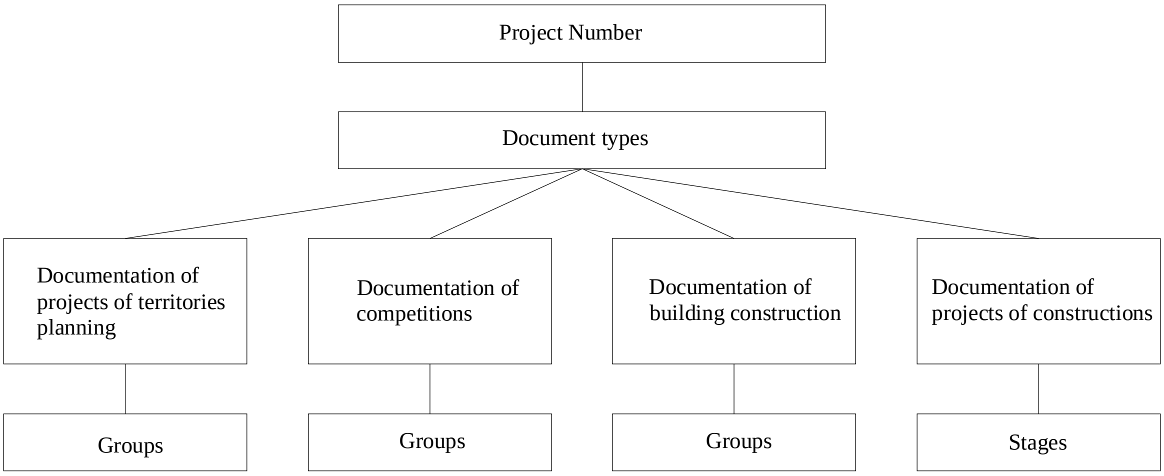

Figure 2: Lithuanian classification of the project documentation

This classification is governed by Lithuanian construction regulatory law [8]. For the illustration one part documentation of projects of the construction is shown separately (Figure 3). Lithuanian standardisation organisations, professional associations, user groups, individual companies don't have unified rules of CAD standards and guidelines in building design industry. This is a first attempt in Lithuania to provide unified reference of all document definitions. On the other hand, this standardized reference is the most important issue for development of the efficient IT applications.

The direct implementation of the document classification system leads to overcrowded hierarchical tree of project information. In order to overcome these difficulties document file naming schema is established for native CAD models. This file naming schema is associated with standardized design document classification. The specific CAD document is named beginning with an optional five digit project code followed by (Figure 4):

- Project number;
- Construction number;
- Project stage;
- Discipline designators;

- Version number.

In a similar way, file organisation structures are defined to represent the hierarchy of the building design project. File directory organization (Figure 5) together with file naming schema provide an effective framework for digital design information archiving.

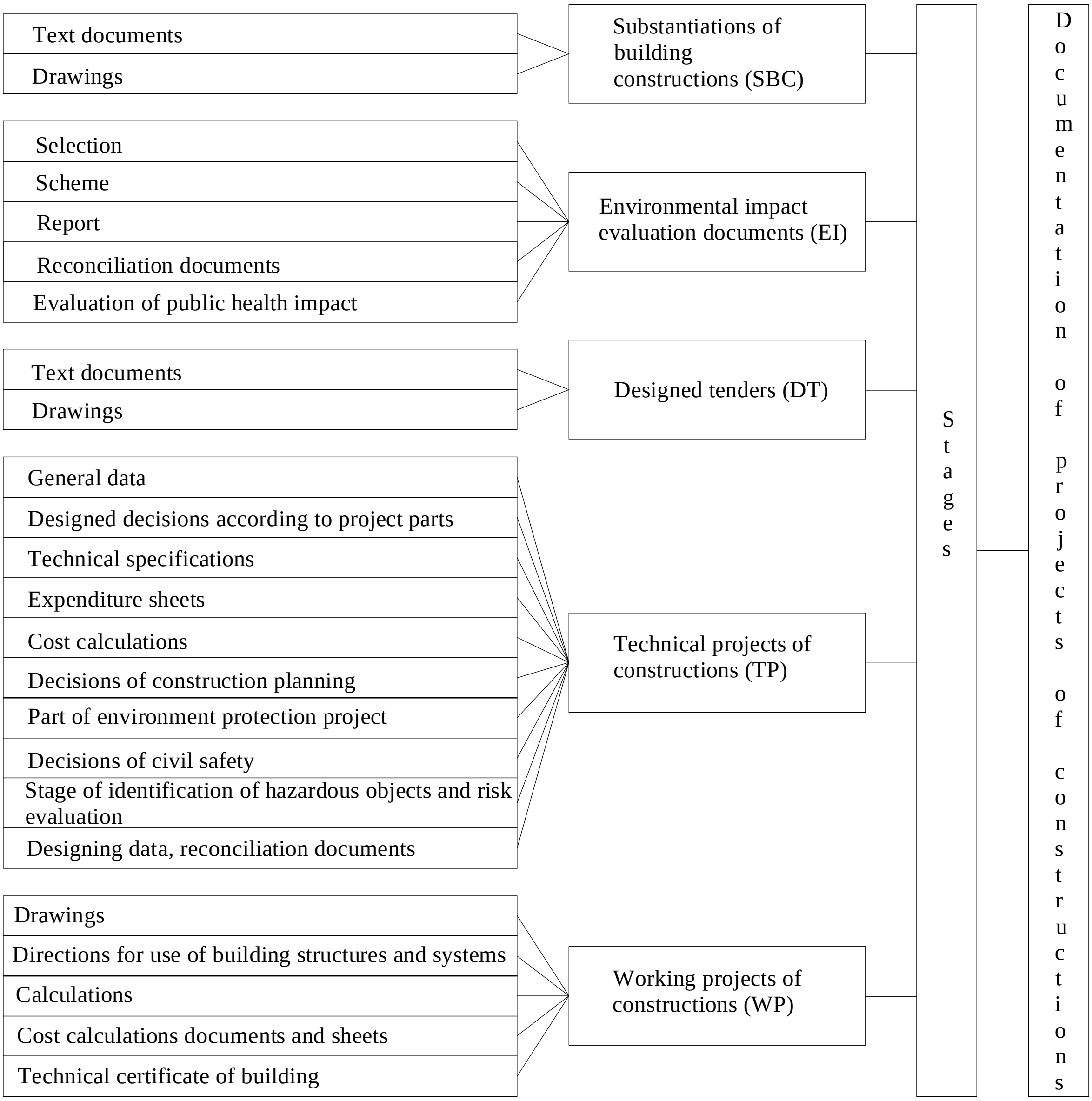

Figure 3:Document classification of projects of the constructions

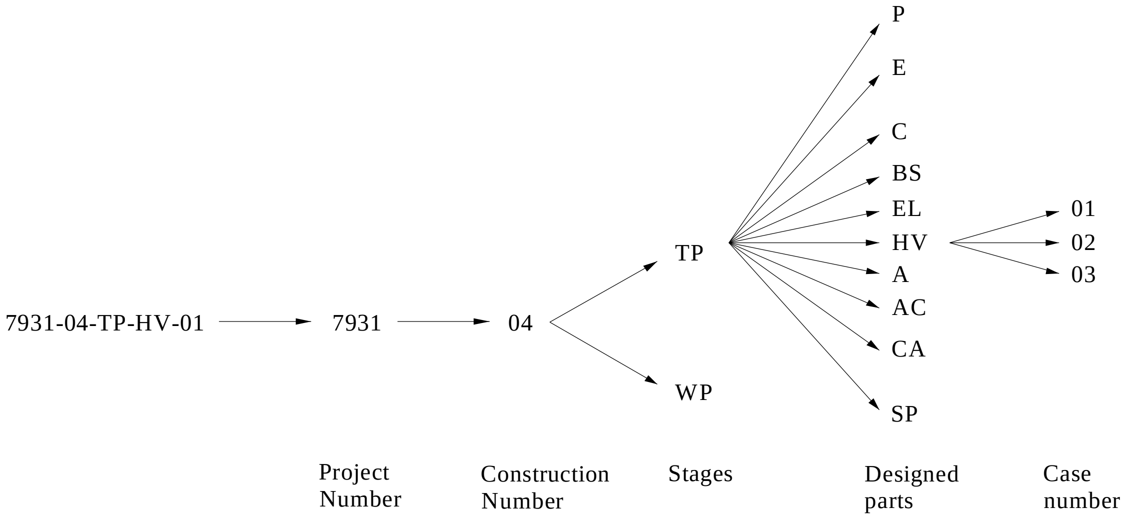

Figure 4: Naming schema of the design documentation

Lettering of designed parts: E – Estimates; C – Communications; EL – Electricity; V – Heating and Ventilation; A – Automation; AC – Architecture and Construction; BS – Building Structures; CA – Calorific; SP – Site plan; P – Plumbing.

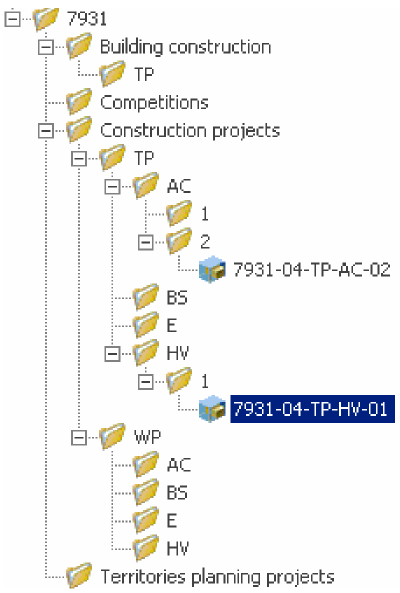

Figure 5: Design information file organization

4. Implementation Technology of AEC Design Archive

For the implementation of the developed model, the AEC digital design archive was chosen, that is “eChange” PDM software of the company ”Empresa Solutions”. For more information about basic features of “eChange”, the interested reader is referred to [1]. While “eChange” was designed with the CAD sector and engineers as the primary users, the system can be used to store any type of file that can reside on a computer’s file system. In our case the largest Lithuanian building design company use “eChange” to manage all of their office documents in addition to the CAD drawings they generate. Lithuanian company performs complete residential and industrial building design that includes architecture, construction and engineering (AEC). UAB Lithuanian Construction Design Institute (Lietuvos Statybu Projektavimo Institutas), which is engaged in the design of construction units and project management has increasing the number of projects per year, at the same time having designed more and more complex objects, the implementation of efficient PDM system has become essential. Tasks that need to be performed for implementation design document archive included (Figure 6):

- Initialization file organization sheet with prescribed project number selection of document format.
- Preparation of electronic document files.
- Automated transmission from SIP to AIP.
- Management of the development team.

The processing of implementation include following steps:

- The design company starting a new project activate structure for a new collection of the digital design data. The project leader or the administrator of the archive initiates this process by entering new project number. By this operation, in the vault of the technical documentation a new tree representing structure of the project documentation is appeared and the SIP of the new project is initialized.
- Each designer of the building design company working with "Architectural Desktop" software and using “Project Navigator” directly connects to general file organization system. By this way separate documents of CAD design are created. Each designer has knowledge about development of the whole project bringing CAD documents into project structure (Figure 5). If changes are made in one part of the project documentation the system automatically shows and other designer can follow what’s going on. That is maintained design chain. At each time the numbers of design chain have information about changes in CAD documents.
- The same tree structure of the project documentation is appeared in the AIP where is “eChange” PDM system. After synchronizing all electronic documents in SIP according to the design parts the archive administrator sets “Archived” status for the documents before that putting them into AIP “eChange” system. By this operation project structure with design information are automatically transformed from SIP into AIP. In AIP all project documents gain “Released” status and if all information is correct documents gain “Archived” status.
- After transforming from SIP into AIP all project documentation obtain metadata properties. The Dublin Core metadata scheme is applied as an initial basis on which the development of more specific relational standard within proposed digital design data archive is performed. There is underway of automated attribution of properties and all documentation that is placed in to project structure adequate catalogues. Hereby all project information being in “eChange” system are accessible for users and groups according to permissions for each document type. The “eChange” system also provides different levels of access rights to documents View/Copy, Check Out/In, Release, Archive, and Delete.

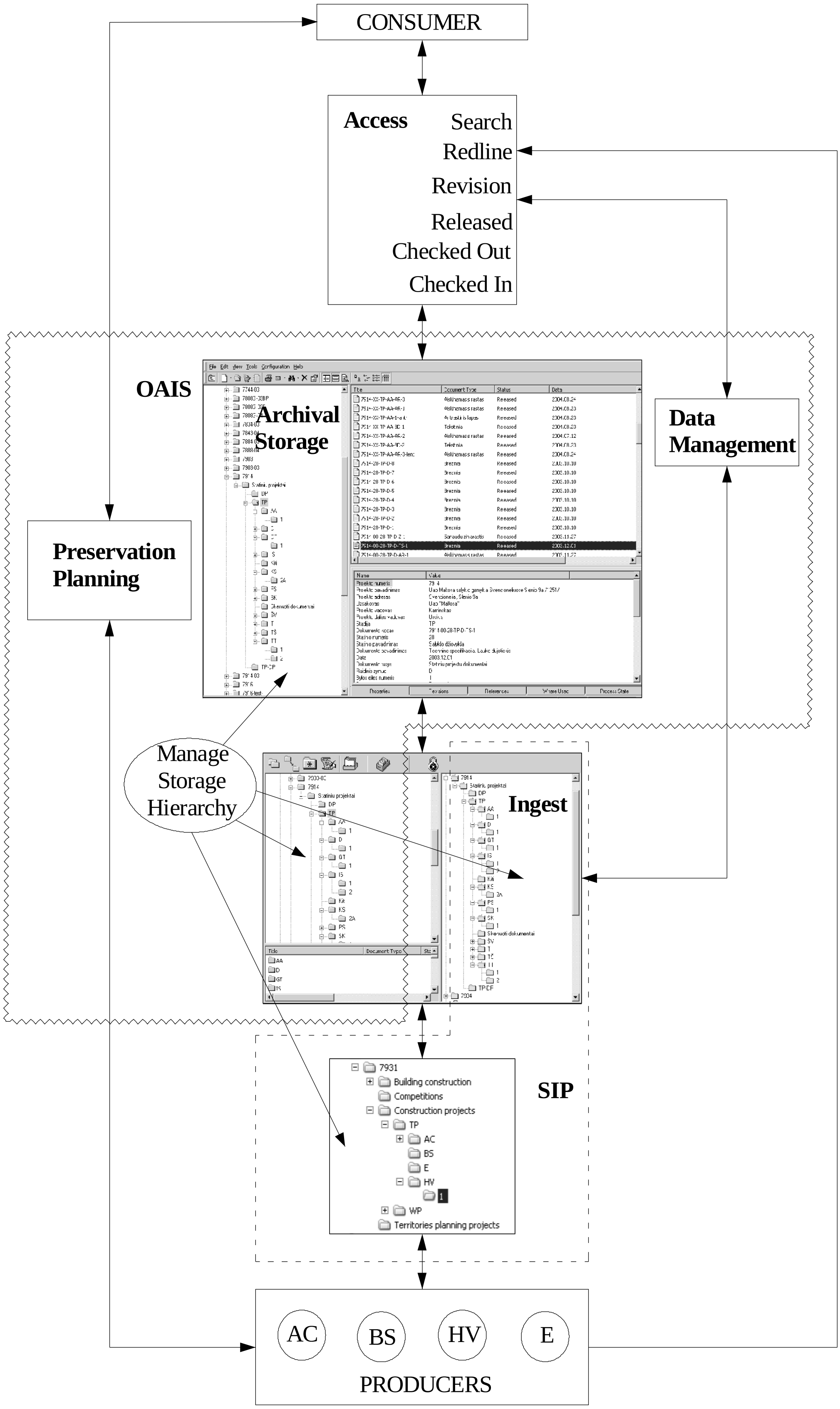

Figure 6: Design information structure

5. Conclusions

The first digital project documentation archive is developed in Lithuanian AEC industry. The modelling of the archive of the construction design documentation is based on reference model for an Open Archival Information System (OAIS). For the creation and management of this archive PDM system of "Empresa Solutions" is implemented. The main strategy was to develop the dynamic archive with information flows in the both directions of the design process chain: consumer-design-archive. The adoption of this digital archive provides a efficient basis for an automatization of Lithuanian construction regulatory rules for building design documentation.

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Transformation of Measured Surfaces of Buildings to CAD Supported Wall Line Model with Joints

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Abstract

The most central and most researched area of construction IT is the design and realisation of new building projects. However, if the building and real estate sector is viewed from the perspective of national economy or the ownership and use of buildings, the management of the existing real estate stock becomes more important.

The manageability of the real estate stock depends directly on the amount and correctness of available input data. The most valid and complete information on existing buildings can be acquired by measuring. Measuring is labour-intensive, but the utilization of results is still technically difficult. Therefore data processing should be as automatic as possible.

This article documents how a measured surface model can be transformed to CAD model. The new approach is based on the use of geometric documentation of intersections and visual marking systems to help the user finish the model.

The solution has been limited to walls and their joints. Other structural elements may be added to the model mainly by intersection methods of CAD programs. For example, a column can be added inside a wall afterwards.

The developed method aims at improving the integrity and technical perfection of models. The connectivity of structural elements is crucial for the usefulness of a model. If walls are not connected, intersections need to be remodelled by the user interface. Without the method presented here, the transferred data could at worst be used as a background image.

Keywords: Measuring of buildings, data transformation, CAD, wall generation

1. Introduction

There are two alternative methods for verifying or retrieving data on the sizes, spaces and structures of existing buildings: either reading the data from drawings or measuring them on site. Drawings have traditionally been made merely to serve the building process. If drawings have not been updated after that, they cannot be considered reliable.

In that situation the real estate sector has an acute need for methods that allow data on buildings to be saved effectively by on-site measurements. Such data are needed especially in renovation planning but they are also very useful for facility management. The main advantage of the on-site measurement method is the validity and completeness of the information

Existing methods for measuring buildings yield a surface model of the building, where the structural elements are depicted by visible surfaces. Invisible structures cannot be measured directly. The surface model is useful, for example, in visualisation.

CAD applications for building design model buildings based on structural elements. If measurements are linked to a special data saving application, the connection of surfaces to structural elements can be stored. A structural element can be generated if all of its limiting surfaces are known. Thus, for example, the surfaces of a fully visible column can be used to generate the actual structural element.

The central structural element in the modelling of a building is the wall, because spaces are usually limited by walls. After defining the walls it is possible to use the model to calculate floor and other areas which are crucial for the occupancy of the building. A major problem with the use of the measured surface model lies with the generation of wall structures, since it is not initially known which wall surfaces measured from different rooms limit the same wall.

2. Wall Generation to a Measured Model

2.1 Measurement of Building

Several methods are available for the measurement of outer surfaces and interior spaces of buildings. The oldest methods are based on measurements with a tacheometer. The method is described, for example, in publication [3]. Instruments designed for terrain measurement can be used to observe the three-dimensional coordinates of individual points. A measurement application can be used to combine the points into surfaces depicting structural elements. A drawback of the method is the slowness of measurement. Every time the measuring instrument is moved it must be set up carefully and its position determined.

The latest methods include modelling based on scanning where the surfaces are formed automatically. The method is described in publication [2] and its commercial application in publication [8]. In this method the distance information obtained by a laser distance meter is added to a digital image. The geometric shape of a surface can be calculated using algorithms derived from photogrammetry. The graphic elements constituting a surface do not necessarily follow the division of structural elements. Data on structural elements must be added to the model through human labour.

The simplest and cheapest measurement method uses a distance meter. A portable computer and a measurement application are also needed. The interface of the application can be used to assign the measured values directly to structural elements and to save the property data of the elements based on visual observations at the same. Although this method also requires much human labour, it is the quickest way to produce a model from measurements inside a building with data on structural elements. The weakness of distance measurements is that they do not include the angle of measurement. Then non- rectangular walls cause inaccuracies that must be addressed separately. There are several software packages on the market that utilise laser distance meters in the measurement of buildings. This method is described in publication [4] and its commercial application, for example, in reference [9].

2.1 Generation of Wall Elements

To enable the generation of structural elements from measured surfaces, the surfaces must be assigned type and material data. Moreover, one surface must not belong to two different structural elements. Otherwise the automatic processing of the model would not be able to make a distinction between such elements as columns and walls.

Many methods that generate walls from wall surfaces require either user intervention or are suitable only for the generation of rectangular walls. Such methods are presented, for example, in publications [6] and [7].

Publication [5] presents a method where wall direction can be used to find the closest other wall surface for each measured surface. The direction is known if wall surfaces of a room are measured in a sequential order when the measurement returns to the starting point. Then the walls can be generated even if the measured wall surfaces are not aligned with the rectangular coordinate axes. The method does not require setting an upper limit for wall thickness, either. The geometric shape of the generated wall base areas is limited to four points. The wall generation method is two-dimensional, which means that the line formed by the lower edge of the wall surface is used instead of the measured wall plane.

3. The Documentation of Wall Intersections by Geometry

3.1 Assumptions

If the wall structure is homogeneous in the vertical direction, the connectivity of walls can be studied based on the intersections of the base areas of the walls. An example of the calculation method is presented in publication [1]. Such a method could be difficult to program because of problems related to calculation accuracy.

The calculation becomes much faster and easier if the intersections can be calculated using lines. Two walls can be considered interconnected if any of their boundary lines intersect. Possible lines indicating an intersection are the boundary lines defining the base area of the wall and other lines defined within the walls such as the centre line of the base area.

The data structure of a wall with a simple geometry can be described by a single line. The wall thickness can be assigned to both ends of the line. The use of this method is supported by simplicity and the utilisation of standard basic functions of CAD applications.

Three-dimensional wall models can be described by base areas if the geometry of the structure does not change in the vertical direction. Then plane coordinates (x and y) remain constant while the z coordinate changes. If height can only change linearly between the end points of the wall, data on the three-dimensional shape can be stored using height data assigned to the corner points of the base area.

3.2 Used Symbols

Intersection types are classified using upper- and lowercase letters. The upper-case letter represents wall properties and the lowercase letter the connectivity of centre lines. The connectivity of wall lines is indicated by a lowercase letter added after the type letter. Connected lines are marked with "c" (connect) and others with "g" (gap).

Wall intersections are divided into intersections of two or more walls. In an intersection of two walls the real structure is usually continuous but the wall has been divided into two elements in the computer model. It was decided to use the capital letter "W" (wall) as the first character of the type designation of this intersection.

Intersections of more than two walls are indicated with a capital "C" (crossing). With such intersections the number of combinations is theoretically unlimited. The classification of these intersections is based on selecting the two walls that form a continuous structure as in the case of an intersection of two walls. All other walls join the walls that form the continuous structure.

The walls to form a continuous structure are determined on the basis of their property data. Exterior walls or bearing walls are primarily chosen as continuous. It is not always possible to reach an unambiguous solution based on these conditions, and additional conditions may therefore be set based on structural thickness and parallelism of walls. In the designations the walls of a continuous structure are indicated by the letters "CC" (crossing continuous).

The fourth letter indicating a wall intersection type is "G" (gable). It is used for cases where a wall gable bounds a space. A gable may be partial, in which case the letter is made part of other type designations. A partial gable is produced if all boundary lines of the connected wall areas do not intersect.

3.3 Types of Wall Joints Classified by Connectivity

In the method presented here walls are assumed to be modelled by lines, which are also used for documenting wall joints. Walls are classified under different categories based on their connectivity. The classification does not depend on the location of the line in the wall base area, provided that the wall line is straight and not, for example, an arc. The examples use the centre line of the wall base area. Intersection type refers to the type of each connecting wall, not the entire intersection.

Intersection types where a wall line is connected to another line are: Wc, CCc, Cc and WGc. Intersection types where the wall lines do not connect are: WGg, CCg, Cg, CCGg and CGg. There may also be walls that end without a connection: G.

Intersection types differ in terms of the intersections of their wall and boundary lines. Boundary lines are defined as discontinuous if at least one line is discontinuous. Then the wall gable bounds a space, and the letter "G" is added to the type designation. The following three illustrations present examples of different joints. There are three different types of two-wall intersections, as shown in Figure 1.

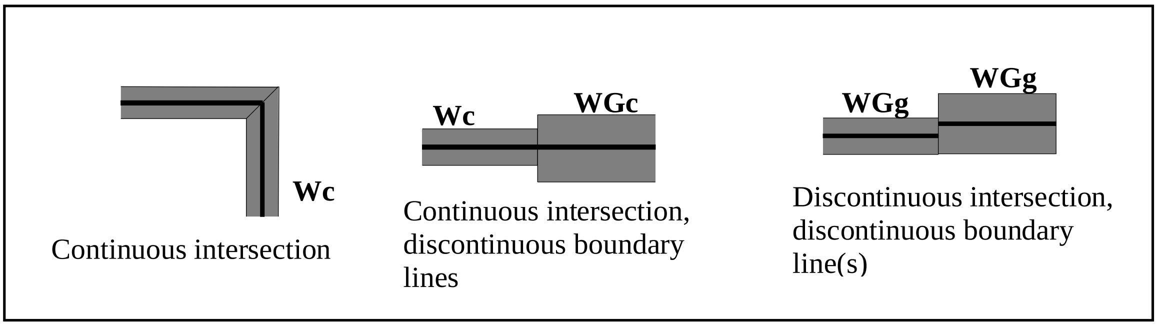

Figure 1. Intersections of two walls.

Figure 2. shows examples of intersections of more than two walls. The walls forming a continuous structure (CC) are darker. In the second example of Figure 2, the centre line of one wall has not been extended to make a connection. This is because one wall would be shortened by the operation. This would also change the original measurement result or the measured surface, which is not permissible.

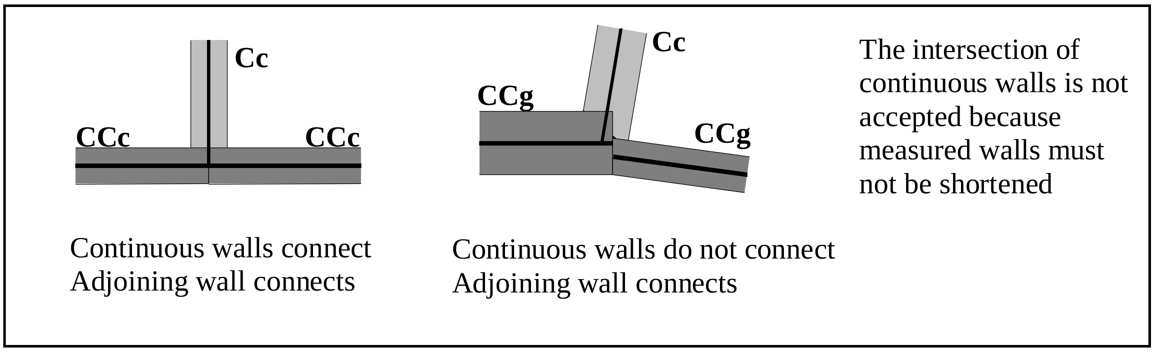

Figure 2. Intersections of more than two walls.

Figure 3. shows examples of intersections of more than two walls where a wall gable bounds a space. These cases occur rarely in actual buildings.

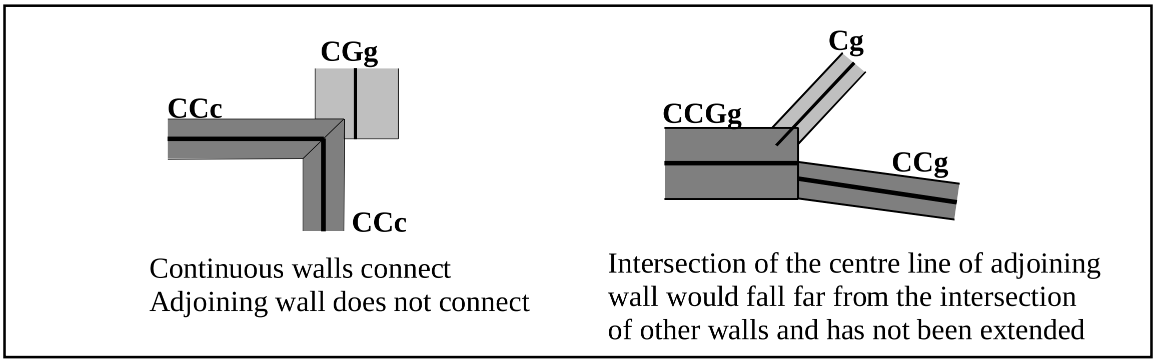

Figure 3. Special cases of wall intersections.

4. Implementation and Results

4.1 Wall Generation

Walls were generated using the method described in publication [5]. In the testing, it was assumed that all walls produced by the measured model are flawless. Actual 4 measured buildings were used as test material. Sample size was too small to be statistically significant, but it gives an idea of whether the method works. Buildings L and N are public buildings of complex architectural shapes. Buildings P and R are rectangular prefabricated buildings. In figure 4. is shown two dimensional drawings of buildings L, N and R. Building P is shown in figure 5.

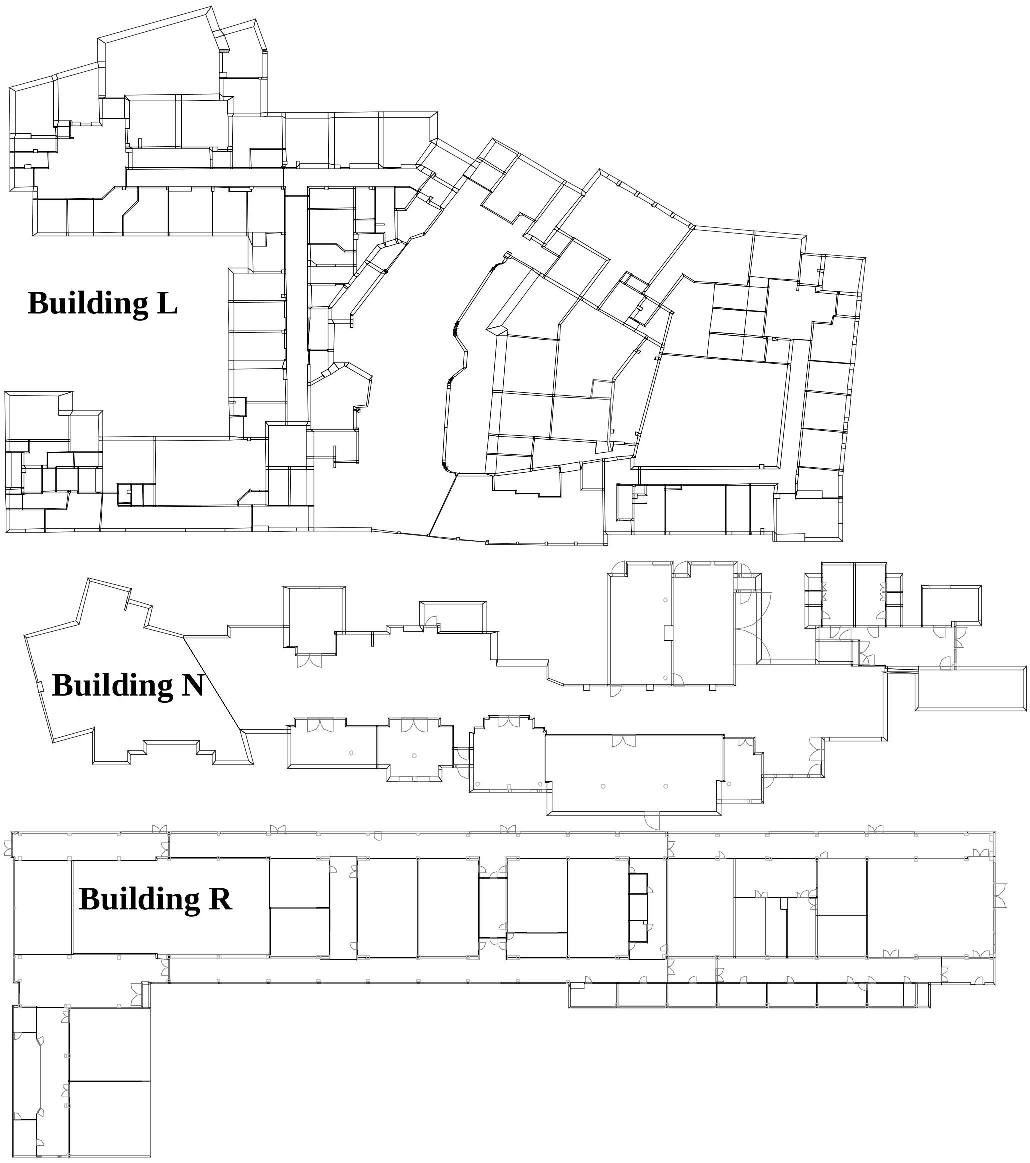

Figure 4. Two dimensional drawings of test material.

Table 1. presents the numbers of generated walls divided according to constant or non-constant wall thickness. If thickness is not constant, it may only change linearly between wall ends, as described above.´

Table 1. The number & percentage of different wall thickness types in the test material.

	Building L		Building N		Building P		Building R	
Thickness	no.	%	no.	%	no.	%	no.	%
variable	801	96.2	25	12.0	11	5.5	26	12.8
constant	31	3.7	182	87.5	187	94.0	176	86.7
unknown	1	0.1	1	0.5	1	0.5	1	0.5
All walls	833		208		199		203	

4.2 Joint Types of End of Walls

The centre lines of the generated walls were extended to intersect each other. Data on the connectivity of wall centre lines were recorded in the database. Different types of wall end intersections were recorded as described in Chapter 3. Table 2. presents wall end types by connectivity.

Table 2. Occurrence of wall end intersection types in the test material.

	Building L		Building N		Building P		Building R	
End type	no.	%	no.	%	no.	%	no.	%
Wc	508	31.1	218	52.7	84	21.1	90	22.2
CCc	150	9.2	99	23.9	121	30.4	77	19.0
Cc	259	15.9	0	0.0	70	17.6	72	17.7
WGc	0	0.0	0	0.0	0	0.0	0	0.0
WGg	132	8.1	30	7.2	20	5.0	46	11.3
CCg	488	29.9	39	9.4	69	17.3	96	23.6
Cg	41	2.5	15	3.6	20	5.0	4	1.0
CCGg	24	1.5	2	0.5	2	0.5	1	0.2
CGg	7	0.4	0	0.0	1	0.3	0	0.0
G	0	0.0	3	0.7	1	0.3	0	0.0
unknown	23	1.4	8	1.9	10	2.5	20	4.9
All ends	1632		414		398		406	
Walls	816		207		199		203	

The case WGc, where the centre lines of two walls connect at the intersection but the boundary lines do not, did not occur in the material. That would be possible only if exactly equal thickness changes were measured from different rooms. Although theoretical, the type cannot be excluded from the classification, because it produces a connection between walls.

Cases where connectivity could not be determined were examined by random samples. In all examined cases wall thicknesses were so small that connectivity could not be calculated. Small wall thicknesses resulted either from measurement inaccuracy or faulty type designations. Imaginary walls of zero thickness dividing spaces were used to facilitate measurements, and were excluded from calculation based on their type designation.

The number of walls is the numbers of wall ends divided by two. 17 of the originally calculated walls in the L building and one in the N building were removed. These walls were also geometrically flawed. For this reason, the number of walls from these buildings is smaller in the connectivity test than in Table 1.

Table 3. presents numbers of wall ends by connectivity. Table 3. reveals that over half of the intersections in all buildings could be documented geometry. On average, two thirds of the intersections in the entire material were documented.

Table 3. Share of connected wall ends in the test material.

	Building L		Building N		Building P		Building R	
Continuously	no.	%	no.	%	no.	%	no.	%
continuous (c)	917	56.2	317	76.6	275	69.1	239	58.9
non-continuous (g)	692	42.4	86	20.8	112	28.1	147	36.2
gable (G)	0	0.0	3	0.7	1	0.3	0	0.0
unknown	23	1.4	8	1.9	10	2.5	20	4.9
All ends	1632		414		398		406	

4.3 Joints of Walls

Table 4. presents the numbers of different intersections. The number of continuous wall intersections is obtained by dividing the number of the respective wall gables (Wc) by two. Likewise, the number of non-continuous wall intersections is obtained directly from wall gables (WGg). The connectivity data of the measurement database allows calculating the number of intersections of at least three walls. In the unknown cases connectivity of walls could not be calculated, and only one wall is connected to the intersection in the database.

Table 4. Number of wall intersections in test material.

	Building L		Building N		Building P		Building R	
Inersection	no.	%	no.	%	no.	%	no.	%
continuous wall	254	41.2	109	61.2	42	28.4	45	28.9
non-continuous wall	66	10.7	15	8.4	10	6.8	23	14.7
joints	291	47.2	54	30.4	94	63.5	88	56.4
unknown	5	0.8	0	0.0	2	1.4	0	0.0
All	616		177		148		156	

4.4 Output to CAD

The model was read from the database by an application written in C language and was transferred to ArchiCAD 7.0 using the functions of the programming interface. Transformed building P is shown in figure 5.

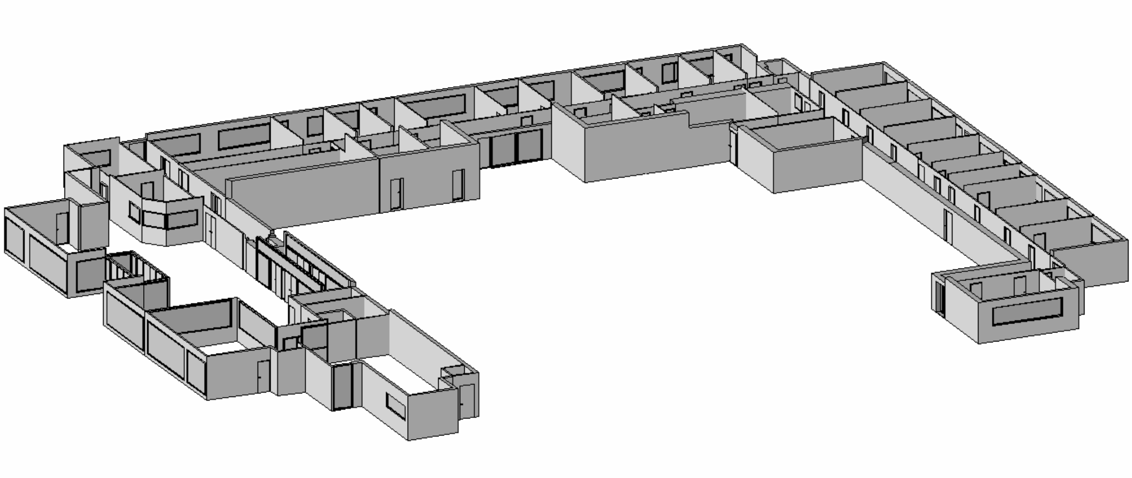

Figure 5. To CAD program transformed model of building P.

In this CAD application the wall line (reference line) may be located in the middle of the wall only if wall thickness is constant. In the other cases the wall line was moved to the edge of the wall when connections between wall lines failed. Building L was not transformed, because only 4% of its walls were of constant thickness

Wall intersections where the centre line of a joining wall did not connect to the others were marked by an alert symbol visible to the user. The example of marked join is shown in figure 6.

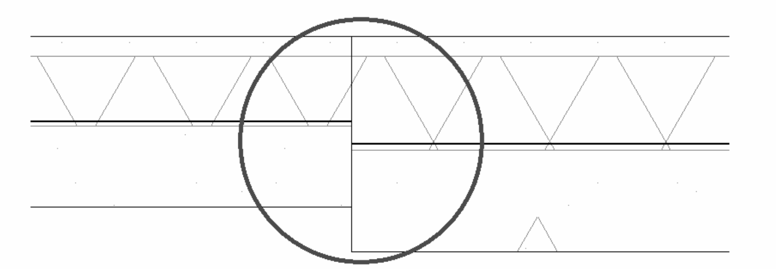

Figure 6. Marking of unconnected wall joint.

The number of marked intersections was calculated from the user interface of the CAD application. Table 5. shows the share of the marked intersections of the total.

Table 5. Intersections marked as non-continuous in the CAD output.

	Building N		Building P		Building R	
	no.	%	no.	%	no.	%
Marked intersections	68	38.2	63	42.6	76	48.7

5. Discussion

The method sets considerable limitations on the model to be used as input data. The requirement can be met by dividing actual walls into a sufficient number of sections in the computer model. In principle it is also possible to assign a wall line to a wall of complex shape, and use it to document connections. This, however, requires a separate data structure to maintain the geometric relationship between the wall area and the centre line. The other possibility is to edit the transferred model by rejoining small walls into bigger ones. This could be achieved by introducing a data structure to indicate which wall sections constitute a uniform continuous wall.

The outer surfaces of the external walls of building are normally continuous between the corners. The distances of wall surfaces between adjacent spaces are difficult to measure in exactly the same way. The wall of the other room may also have a special surfacing which makes it thicker. In both cases the result is that the centre lines of the external walls do not meet. Then the connectivity of intersections would be better if the outer surface were selected as the wall line.

CAD data transfer could be improved considerably. It can be assumed that the features, and in particular the programming interfaces of applications, develop constantly. With new CAD software versions theoretically calculated connections will before long be also attainable in practice.

The geometric documentation of intersections could also be used for general data transfer between CAD applications. Unlike in the measured database, it can be assumed that in the CAD model almost all walls are joined before transformation. The data transformation features for walls of CAD applications could be developed so that connections would occur in most cases. The location of the wall line could also be optimised to enable connectivity in as many intersections as possible. It is important that the method presented here is independent of the CAD application.

6. Conclusions

The main result of the tests was that about two thirds of wall intersections could be documented by geometry, even in the case of complex wall geometry. This leads to the conclusion that if the geometric model of a wall can be reduced to a line, the connectivity of walls can often be documented by simple markings and ten intersection types. The documentation is based on the intersections of wall lines, which means that connectivity can be expressed using geometry. This also means that the model can be transferred between applications with a minimum of external definitions.

Connections between all walls could not be achieved in any of the tested models. The detection and marking of non-connecting points reduced the work of revising and complementing the model considerably. Without the markings, the finding of a single flawed joint would have required reviewing all intersections. The number of connected walls is large enough to use the method compared to the situation where the connectivity of walls is not known.

Acknowledgements

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UK Construction Processes and IT Adoptability: Learning from Other Industries

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Abstract

Process improvement has been identified as a mechanism of achieving the desired performance improvements of the UK construction industry. During the recent past, researches within UK construction process improvement research paradigm have been influenced by the initiatives of other industries like manufacturing and software. Despite the success stories within such industries, the unique characteristics of the construction industry demand a careful consideration of the applicability of these approaches within a construction environment. Based on a literature review carried out by the authors, this paper discusses the nature of this applicability issue further.

In addition to the above applicability issue, construction industry has suffered from a slow information technology (IT) adoptability issue, while IT has been considered as an effective enabler for process improvement in other industries. This has hindered the potential synergetic benefits of using IT within construction process improvement strategies. As such, it is important to understand the reasons behind this slow IT adoptability in order to ensure successful deployment of process improvement initiatives within the UK construction industry. This paper discusses this issue, by reviewing the literature to compare IT adoptability issues of the UK construction industry and other industries, with the aim of learning lessons from those to improve the UK construction industry.

Keywords: UK construction industry, construction process improvement, IT adoptability, IT-process co-maturation, construction IT

1. Introduction

The need for a change within the UK construction industry is discussed within number of studies during the recent past [1,2,3,4,5]. Growing dissatisfaction found among both its private and public sector clients has been an effective motivator for these discussions [6]. These dissatisfactions are often attached to the poor performance of the industry. The required change has thus been identified to be in a form of performance improvement. Further studies about this requirement have revealed that the fragmentation and confrontational relationships are the major inhibits for performance improvement initiatives [4,3,5]. Fragmentation and confrontational relationships are sharpened due to the traditional functional view of construction projects, where the tasks are assigned to individuals based on their functions with minimum attention given to the integration issues [7,8].

Having identified this nature, Egan [3] highlighted that “focusing on the customer” and “integrating the process and the team around the product” as two of the key drivers to achieve the desired change within the UK construction industry. This emphasises the need of deviating from functionally oriented project structures towards a customer focused, process oriented project delivery mechanisms. It appears that the above recommendations from Egan are based on the view that the process improvement is the way forward to improve the performance of the UK construction industry [9].

2. Process Improvement

2.1 What is Process Improvement?

In literature “process” is often defined as a set of related activities attached to outputs, value and customers [39]. Davenport [10] states that “a process is simply a structured, measured set of activities designed to produce a specified output for a particular customer or market”. Hammer and Champy [11] defined a process as, “a set of activities that, taken together, produce a value to the customer”. As identified within above definitions, the process view integrates the product, procedures and the customer, so that the stakeholders of an organisation can view the big picture which they are contributing to. This essentially synchronises the individual functional objectives with the overall organisational objectives, enabling opportunities for improvements.

Literature covers a wide spectrum of terms related to process improvement. Business Process Improvement, Continuous Process Improvement, Business Process Re-design, Business Re-structuring, Business Process Re-engineering are some of those which appear frequently within literature [12,13,14,15,16]. All these concepts appear to have the major objective of achieving performance improvement within organisations, but vary from the magnitude of the desired level of change. It varies from continuously improving the processes to total re-structuring the organisation [17]. This determines the two extremes of the process improvement spectrum and defines the two major approaches to process improvement, the evolutionary approach and the revolutionary (radical) approach [18]. Within literature some times the term “process improvement” is synonymously used with the evolutionary approach and “process innovation” is synonymously used with revolutionary approach. Within this paper, “process improvement” is used for both the cases, and where appropriate, evolutionary and revolutionary approaches are explicitly indicated.

2.2 Process Improvement in Construction

Recent construction literature show a clear focus on construction process improvement strategies. Within these literature, the best approach for construction process improvement is often debated (see: [4,19,20,21]. Historically, most of the process improvement strategies have evolved within production line based industries like manufacturing. Business Process Re-engineering (BPR) is one such strategy evolved to address the supply demand gap existed within most of production line based industries during early 90's due to the globalisation trend. BPR is an attempt to eliminate chronic wastes within processes in practice, by introducing new processes. The focus here resides within the ultimate outcomes of the processes in place rather than on the processes it self. Thus the existing processes attract minimum attention when designing new processes and a whole new set of processes could be the ultimate result. Due to these radical changes to processes, often this approach claims to produce significant level of improvements. Despite being a fashionable theme within some of the industries, BPR has received number of criticisms as a construction process improvement strategy (see: [4,19,20]). Considering the applicability of this approach, Love and Li [4] pointed out that the implementation of the BPR within construction is difficult due to the fact that the array of construction have not been designed systematically but have evolved in an ad-hoc manner. Further, direct applications of BPR in construction might lead to complications, due to the fact that the construction often consists of complex supply chain arrangements. Due to these complex relationships, there is a danger that the re-engineering exercises might impose negative effects on construction organisational processes, which would not be apparent for some time after implementation [22]. In addition, since BPR pay less attention to the "human side" of an organisation [23], it may adversely effect the construction organisations as it is perceived as labour intensive.

Another process improvement strategy visible largely within manufacturing and automobile industries is the Continuous Improvement (CI). This is an evolutionary approach, based on the statistical process controlling. This strategy has its roots in the Japanese "Kaizen" approach to quality control, and to the Total Quality Management (TQM). It concentrates on planning and monitoring existing processes with the aim of continuously improving the same. The main problem of this approach, when applied to construction, is based on the project based nature of construction. Unlike in a production line environment, it is difficult to identify a linier relationship between processes in place within a project based environment. This limits the possibility of setting targets for processes in place and hard to monitor the performance of the same. On the other hand, this approach is largely depending upon repetitive nature of the processes visible within the production line environments. Thus, the "unique" nature of the construction product questions the applicability of this approach within a construction environment.

However, the above problems do not eliminate the possibility of using the principles of above process improvement approaches within a construction environment. As Lillrank [24] pointed out, the innovations in one industry do not provide direct solutions to the problems of other industries. Rather those innovations have to be recreated within the receiving industry considering the capabilities and the characteristics of the same.

Considering the apparent problems above, some studies have suggested that, irrespective of the approach to process improvement, construction organisations need to embark on adopting quality management principles if the desired improvement to be achieved [4]. Within this context, it is suggested that an underlying process improvement culture has to be established before embarking on process improvement initiatives [4,8]. The major emphasis here is to prepare the organisation to receive the process improvement initiatives by increasing the capability of the organisation in question. Considering the different maturity levels of different construction organisations, a stepwise approach to process improvement is suggested by some recent studies [9].

Being a project based industry and showing some similarities to the construction, software industry has exemplifies a successful process improvement initiative based on the principles above mentioned. This approach has gained its popularity under the name "The Software Capability Maturity Model (CMM)". This model was developed for the US department of Defence (DoD) who is a major software purchaser [25]. The use of CMM includes the evaluation of software manufacturing organisations prior to award them contracts. CMM is based on a five levelled structure. Within this, organisations are ranged from level 1 to level 5 based on their maturity. Within this framework, a maturity level has been defined as "a well defined evolutionary plateau towards achieving mature processes. Each maturity level provides a layer in the foundation for continuous process improvement" [26]. Level 1 organisations are the least matured organisations where as level 5 organisations being the most matured organisations. In order to achieve a specified maturity level, organisations must satisfy all the key processes defined within the immediate below maturity level. The organisations are tested against "key enablers" to determine weather they have satisfied each key process. Through this framework, organisations are guided to adopt stepwise process improvements. This framework ensures that the organisation in question is ready for the next level of process improvement. This, intern initialise a process improvement culture within the organisation and guides the procedures and the people towards improvements, using the available and potential tools.

Sarshar et al [25] have attempted to apply the principles of this model within the construction industry. This attempt was named as the Structured Process Improvement in Construction Enterprises (SPICE). This research was carried out in stages, and currently, the dynamics up to the level 3 of the CMM were explored and customised to the UK construction industry (See: [9,25] for further details about this approach). While lower maturity levels of CMM establish the required capability and the background of the organisation, the higher maturity levels are responsible for dramatic and sustainable process improvements. Within the SPICE, the dynamics of higher maturity levels were not explored thoroughly, leaving its full potential unexplored.

The above exemplifies that possible solutions for some of the problems identified within the construction process improvement, have already been explored within other industries. A careful consideration of the characteristic differences and unique requirements of the industries in question should then provide a mechanism for sharing knowledge between industries.

Apart from the process control mechanisms explained above, the information technology (IT) has been identified as the major enabler of the process improvement [10]. However, the construction industry has been criticised for its slow IT adoptability [27]. Further more; the industry has become frustrated with the falling of IT as many companies have invested in the wrong technologies without addressing the business needs [28]. The following section discusses the stand of the role of IT as an enabler for the construction process improvement.

3. Process Improvement and Information Technology

3.1 IT for Process Improvement

While process improvement is not purely a technological endeavour, Information Technology has been identified as a key process improvement enabler [10,11,29]. Within this context, new advancements of IT triggers new operational and management processes within organisations, creating a technology push for process improvements. On the other hand, the process improvement initiatives create an opportunity to change existing processes to be benefited from existing information technologies in place, creating a process pull for technological advances. This reveals a concept of duality between the process improvement and use of information technology [30].

The slow IT adoptability does not mean that the construction industry lags in implementing IT systems; rather, it suggests that the construction industry lags the other industries in impact of IT to the business [31]. Even though the issue has been identified as lack of awareness of how to exploit technology, a careful consideration of the "lack of awareness" relates the problem to the roots of "processes", as often immature management processes are responsible for internal and external communication gaps. In other words this suggests that, proper processes have to be in place in order to harness the actual benefits of the IT capabilities within construction organisations.

On the other hand, it could be argued that information technology has created a significant impact on some of the work patterns and processes of organisations irrespective of their industries. As an example, it is difficult to identify a an organisation today, which uses any report producing, letter writing mechanisms or tools other than personal computer based word processing solutions even within the construction industry. Further, emails have become a powerful and commonly used communication media commercially and individually. A survey conducted by Construction Industry Computing Association [32] based on over 400 construction organisations revealed that 97% of the construction organisations have access to email. Further, computer aided drafting tools such as AutoCAD have shown influential impacts during the recent past, and traditional drawing boards are becoming redundant rapidly. Above exemplifies the fact that, irrespective of processes in place, IT has influenced organisations to change their work patters and processes. This further stresses the existence of the concept of duality within the construction industry as described above.

4. IT as a Change Agent

The concept of duality discussed above, creates a clear link between the organisational processes in place and the IT adoptability. This suggests that IT adoptability in a particular industry or an organisation, especially with the intention of improving its performance, should not depend entirely on the capabilities of the technology in question. Rather, the organisation and industry specific characteristics and processes in place will have to be investigated prior adopting such technologies. The next section discusses some evidence from literature highlighting IT usage patters of construction and adoptability problems visible within other industries especially related to processes in place.

4.1 IT Usage Patterns in Construction and Adoptability Problems

In order to understand the IT adoptability problems within construction, it is vital to identify the IT usage patterns within the construction industry and at the same time it is important to identify the drivers behind these usage patterns. A study carried out by Construction Industry Computing Association (CICA) gives an insight to the IT usage patterns and drivers behind the IT usage in UK based construction companies. 73 construction related companies were surveyed and one of the objectives of the study was to identify the drivers of the investments in IT [33]. It is visible from the survey results that the IT investments in construction is generally driven by short term tangible benefits rather than long term strategic benefits. For an example, the survey results reveal that general client expectations / requirements attracted 68.5% response rate as a driver for IT investments where as only 17.8% have indicated strategic board level decisions as a driver for IT investments in construction. On the other hand it is visible from the same survey that an imbalance between the technology-push and process-pull is visible within the industry. For an example, 60.2% and 40.0% of the respondents have indicated that affordability of technology and exploration of new technologies respectively as a drivers for IT investments where as only 32.8% respondents have identified process improvement as a driver for IT investments. The statistics show that construction lacks the strategic usage of IT. It also reveals that IT usage within construction is largely technology push driven.

Few facts can be highlighted as reasons for this. Most importantly, there is a clear communication gap and a conflict of interests between the IT implementations and decision makers. This gap is widened due to the absence of dedicated IT specific functions (roles) within most of the current construction processes. This leads to another reason for the visible gap between actual IT potential and its usage, a lack of formal approach to incorporate IT within organisation’s development plans. It is also visible that the current usage of IT within most of the construction organisations are based on short term objectives such as gaining speed, minimising human errors, etc. And in many cases, little consideration has been given to understand the function of the system in relation to the business [34]. Thus the short term, tangible benefits of IT, has become the driving force of IT adopting policy, while hindering the possibilities of tailoring IT to support actual system and process improvement requirements. Hence, it is also visible that current IT usage within the construction industry is more functional oriented.

This leads to the problem of IT stagnation within the construction industry, as the use of IT is not being looked at from an organisational wide angle rather from an individual, functions based angle. This has witnessed by some of the existing IT usages. Software based project planning tools are widely being used within the construction industry. But the fact that, it is being used in an uncoordinated manner has hindered the possibilities of using those to the maximum potential. For an example, most of the modern project management software (e.g. MS Project) are capable of analysing financial capabilities and requirements (e.g. cash flows forecasts) of organisations in addition to the obvious scheduling capabilities. But at point of usage, most of these functions are neglected due to the functionally oriented work patterns. This complies a classical example of the need for an industry wide, process based approach to IT implementation strategies within the construction industry.

The above situation drives the construction industry to a dilemma, in terms of the process improvements and the use of IT. It is important to have matured processes that support IT integration to enhance the maximum benefits from IT capabilities, and at the same time, new IT capabilities lay solid foundations for successful process improvements [30]. This is not a construction specific problem; rather it is visible within some of the IT adoption initiatives of other industries. The following case highlights a similar scenario within the healthcare sector.

4.2 An Example from the Healthcare Sector

A number of information technologies have been adopted in medical practice over the last century [35]. Some of the attempts to adopt various technologies have found ready acceptance (e.g. digital transmission of X-Ray images) while number of others have failed so far to gain acceptance [36]. Videoconferencing has been one of such technologies which have been tried since 1950s in several countries [37]. Bower et al [36] have investigated the adoptability of videoconferencing technologies within the health care sector and have presented some insights to the problem.

A technology push for the use of video conferencing in Scottish healthcare sector was visible due to the rapid fall of equipment prices, improvements in quality of transmission and installation of the basic telecommunication infrastructure. This was further reinforced by the policy pull of the Scottish office since 1998. The Scottish office has advocated proactive adaptation of visual communication technologies in healthcare to share the same basic communication infrastructure with other information and communication technologies in place [38].

Despite the strong encouragement from technology push and policy pull for adopting visual communication technologies in Scottish healthcare sector, [37] have sighted a study of ICTs in Scottish healthcare delivery, which concluded that rejection of innovations and technologies was probable where these have shown significant disruptions to the crucial process of the established practices. It has further been emphasised that the problem was evident in use of videoconferencing where it had the potential to change the clinician / patient relationship and the relationship between the professional groups within the health care delivery context. Moreover, Bower et al [38] highlight that organisations with unstructured and ad-hoc processes have more tendency to reject new technology and innovation.

This example case stresses the fact that the mere balance between technology-push and policy-pull (again technology driven) does not provide the perfect platform for IT adoptability. The strong processes and cultural concerns have a major impact on innovations and technology adoptability within a particular industry. Construction industry can also put within the same context, as it demands strong relationships between various stakeholders as with the clinician / patient, professional groups relationships within the example above discussed. Further, it emphasises that the construction has the potential to take the examples from other industries and as exemplified by this case, there is a need of compiling a balanced and process oriented IT adoptability strategy. Further, this demands the construction to consider this IT adoptability strategy as an integral part of its process improvement strategies.

5. Conclusions

Process improvement has been identified as a mechanism to improvement the performance of the UK construction industry. Despite the various strategies available for process improvement initiatives, the characteristics of the construction product and the industry have created a discussion on direct applicability of those initiatives within a construction environment. Identification of these characteristics enables the construction industry to evaluate other industries experiences within a construction specific framework. Success stories of process improvement within the industries like manufacturing and software then provide a platform within the construction to learn process improvement lessons from other industries.

A close relationship is visible between the information technology and some of the existing process improvement initiatives. Construction industry has shown a slow IT adoptability creating concerns about synergetic benefits between IT and process improvement in construction. Studies related to IT and processes have identified a duality between the IT adoptability and the organisational processes in place, emphasising the importance of considering IT adoptability strategies within process improvement initiatives. Some literature have provided empirical evidence from the industries like healthcare to strengthen this importance specially to justify the significance of considering industry specific characteristics and processes within its IT adoption strategies. Similarities and differences between other industries and construction provide a comparison basis to evaluate the ability of the construction to learn these lessons from other industries with the aim of maximising the synergetic benefits of IT adoptability and process improvement.

Since this discussion has considered the common characteristics of the construction product and the production process, the genaralizability of the above conclusions are straightforward. This means that even though the examples discussed within this paper based on the UK construction industry, the arguments built upon those examples can easily be validated to the construction industry beyond geographical limitations.

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Section II

ICT in Facilities Management

The Design of Best Practice Framework in Information and Communication Technology Management in Facilities Management: Case Study in Malaysia

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Abstract

Information and Communication Technology (ICT) become more important nowadays. The Malaysia government has also define attractive policies to make our economy environment more attractive such as Multimedia Super Corridor which is emphasize the implementation of ICT in various economy sector and also to make ICT as an important agenda. This includes facilities management sector in Malaysia. Therefore, this research will be planned to build a best practice concepts of ICT Management Framework for facilities management in Malaysia. This framework is a strategy and synergistic combination of a number of key components, working in tandem. The framework is best viewed as an interconnected triangle consisting of three key elements, namely, people, infrastructure and applications. The ICT Management framework must identify the importance to innovation of building strong link between ICT and facilities management sector. These will enhance facilities management sector capability to produce and deliver globally competitive product and services, to facilitate growth.

Keywords: Best practice, frameworks, facilities management, information and communication technology

1. Introduction

As the use of computers and telecommunications have changed over time, the portfolios of information systems suitable to an era of inward-focus automation of basic activities are unlikely to be suited to an age which focuses on information to support executive decision making, connect the organization to another organizations in the business environment. According to Konsynski and Tapscott (1992), ICT is a factor in contemporary business environment to growth and as agent to link between two or more organizations with distinct and probably different structures, strategies, business process and organizational cultures. The companies must take part and alert with new ICT system because to enter in globalization business, all the management system must be up date and all staff in the companies should know about ICT very well especially for the management.

All the companies in Malaysia must take action to build their company ICT system and there must have a good ICT framework. Framework is very important because framework is a collaborative community based effort in which these commonly needed data themes are developed, maintained, and integrated by organizations. Companies see the framework as a way to share resources, improve communications, and increase efficiency. Framework is best viewed as an interconnected triangle consisting of three key elements, namely people, infrastructure and applications. Many types of organizations participate in developing and use the framework for their management. Although different organizations have characteristics data use pattern, all organizations need different resolutions of data at different times, particularly when they are working together. The framework represents a nationwide community for data sharing, and provides the benefits for the companies as a guideline to involve in globalization market.

Developing the ICT framework take a long time but, it is very important especially for facilities management in the companies. In Malaysia, facilities management stills a relatively new concept, which makes it difficult to present a definitive description. Facilities management can be described as multifarious because of the diversity of its core component such as technical, financial, administrative and management skill.

The scopes of facilities management will depend mostly on the company of which it is a part. Some companies may consider that the facilities management department should manage all non-core activities. This could therefore include departments such as purchasing, accounts, legal, and travel. Other companies may have their facilities management department incorporated into another support service function, such as finance or personnel. Nowadays, facilities management has become a profession. Quite different from the role taken on by the engineer in the early eighties which was described by Becker "Facilities management resided in the boiler room not the boardroom" (Becker, 1990). Facilities management is important and the companies should take serious with facilities department.

The companies can manage their facilities management very well if they have a good system. For this situation, a framework is important to clearly for organize their company as a guideline and basic step to make any changes their process management to enter in era globalization.

2. Materials

2.1 Information System Planning in the Modern Context

By the mid 1990's, it was arguably reasonably well established that some sort of formalized strategy information system planning was an appropriate undertaking for most organizations. Information system planning is to be closely allied to the organizations business planning activity, the accept wisdom at the time suggesting that ICT should only be attempt once a business strategy have been develop and articulate, and hence understanding reach of direction the organization planning to follow for the next few year, its goal, objectives, core business processes and its changes agenda, for examples. With this business strategy establish and share understanding reach among executives, an information system plan could be develop, determining the information and information system needs to support the business strategy, and thus guiding investment decision into the future.

An interactive and generative process is envisaged, recognizing a general trend of establishing a business strategy, then an information system strategy, and finally information technology, but acknowledging the constraints and pressures in the real world which may act to limit the strategies somewhat. Given the rate of technology change, and the potential and impact that modern ICT could have directly on business strategy, and the outset o this process it is important to be aware of technological advances that may impact or alter the chosen or desire course for an organization (Peppard,1993; Liedtka,1998). The examples for the strategy framework it shows at Figure 1.

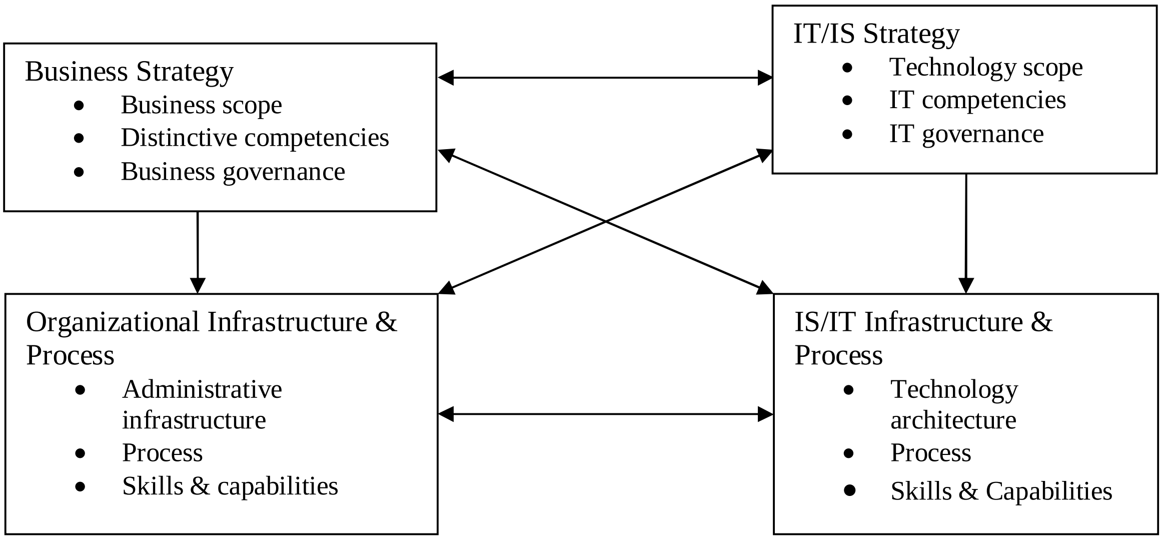

Figure 1: Achieving Strategic Alignment (Adapted from Henderson and Venkatraman, 1994)

3. Rationale for Facilities Management

Most buildings represent substantial investments for organizations and usually have to accommodate and support a range of activities, taking into account competing needs. Within those activities is the organization core business, for which an appropriate environment must be created in buildings that may not have been designed for the purposes on organization might be on its core business, it cannot lose sight of the supporting services-the non-core business. Company may have already considered the distinction between their core business and non-core business (such as cleaning and security) as part of the drive to deliver customer satisfaction and achieve better value for money. Since running costs account for a significant part of annual expenditure, there is bound to be pressure to look for savings in non-core business areas. Cutting operating budgets may be a financial expedient, but may not foster the company's long term development. Since the running of a company involve complex, co-ordinate process and activities, it is necessary to take an integrated view. A piecemeal approach to cutting costs in unlikely to produce the require savings and may impair the company's ability to deliver high-quality services.

Facilities management can therefore be summarized as creating an environment that is conductive to carrying out the company's primary operations, taking an integrate view of the services infrastructure, and using this to deliver customer satisfaction and value for money through support for and enhancement of the core business. Facilities management also can describe as something that will sweat the assets, that is make them highly cost effective, enhance the company's culture and image, enable future change in the use of space, deliver effective and responsive services, and provide competitive advantage to the company's core business. Relationship between core and non-core business in company shows at Figure 2.

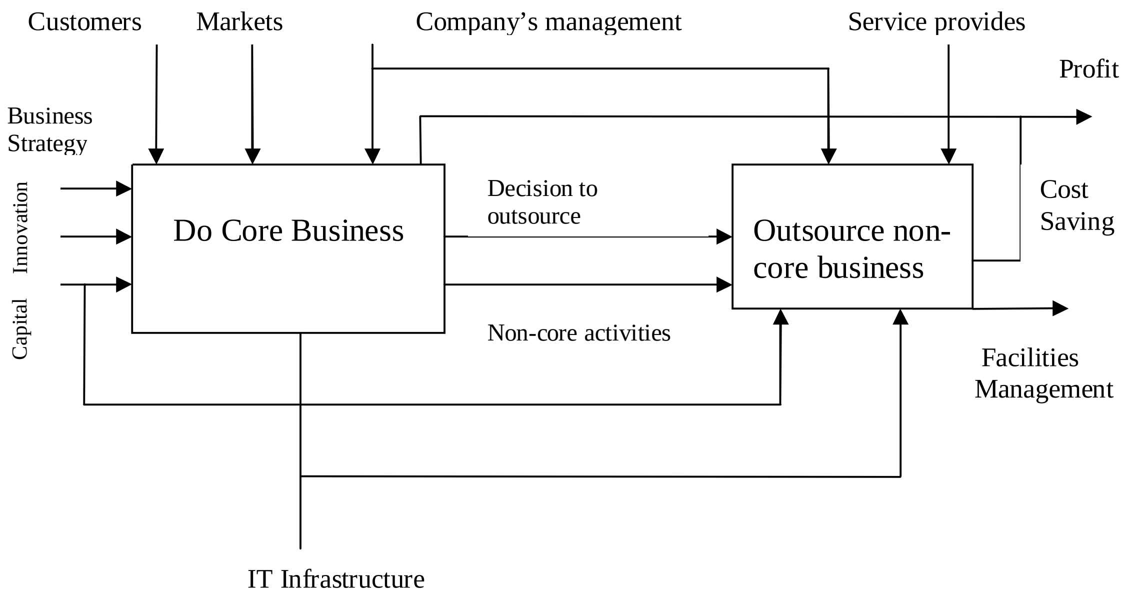

***Figure 2**: Basic relationship between core and non-core business*

Company may not be aware of the extent to which value for money in facilities management can be improved. There are common themes and approaches to facilities management, regardless of the size and location of buildings, although these may not necessarily result in common solutions to problems. In some cases, estate-related and facilities services outsourced (contracted out) and in others retained in house for good reasons in each case. There are also many companies that operate what might be described as a mixed sourced in some measure as well as being retained in house. Whichever course of action has been taken, the primary concern is the basis for the decision. Where the companies approach has been arrived at for entirely proper reasons, such as demonstrating better value for money from one approach as opposed to the other, facilities management is working effectively.

4. The development of ICT in Facilities Management

The use of information technologies without the overarching direction of and information system, more often than not, leads to generation of voluminous, poorly focused and irrelevant information. The creation of excess information in this way is a good reminder of the need to evaluate an information system on the basis of a cost-benefit analysis. The lack of information on products and components in terms of usage and cost can lead to difficulties in focusing the role of Facilities Management and establishing the supply chain within it. Difficulties in monitoring and tracking financial information can also prevent efficient budget control, accurate estimation of work, and contract and purchase management. Good planning in maintenance, operation and refurbishment can be hindered by the availability of life cycle information that is, for instance, crucial in the planning the replacement of components.

Currently, there are no standards that support information exchange and sharing across the building life cycle. Given that there is potential for improvement in business process though the exchange data on the facilities management process, there is a growing need to investigate the issues involve in developing a standard that can benefit this most important part of the business life cycle. This standard could then be use to assist in the development of an information management system to support the exchange of information and the assessment of facility requirements. Such an information system requires a large volume of data. Accurate assessment of a facility's needs requires knowledge of equipment standards from a design and construction information systems, access to accurate maintenance records and repair and replacement costs, access to operation and occupancy information, other operating costs, space management data, operation standards and data from occupational and health and safety information system and from a financial and commercial information system. An integrated information system as shown in Figure 3 could assist facility managers and other project tem members to combine data and information on a facility's life cycle, and base on the integration of cost and commercial data, design and manufacturing and construction data together with facility operation and maintenance data.

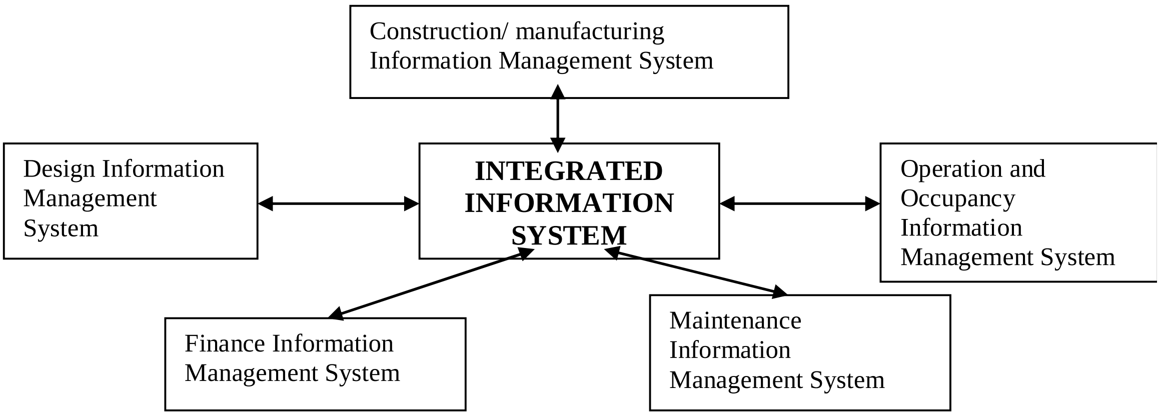

Figure 3: Integrated Information Management System

Technology systems used in FM have developed along a similar timeline to the development of technology in finance and accounting. Figure 4.0 is a diagrammatic interpretation of the fundamental components of an FM technology system. The arrow indicates the communication pathways between the various components of the system. Where each component is physically located is unimportant to the user of the system. There are four aspects that are fundamental to all information technology applications. They are relational databases, networking infrastructure, computer aided processes and data communications technologies. In present FM systems data communications technology is equivalent to Internet technology. Additionally, FM technology tracks advances and applications of technology to management in the manufacturing sector and to changes that have occurred in the management of workplace. Figure 5.0 illustrates the relationship between FM technology and management innovation (Stuart Smith, 2003).

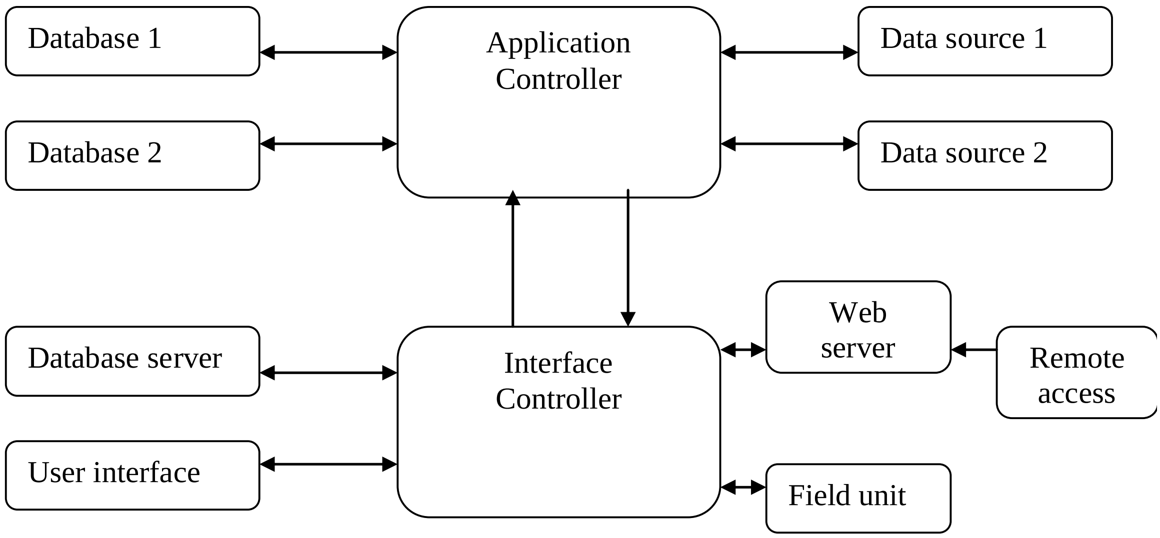

Figure 4.0: Basic components of an FM system

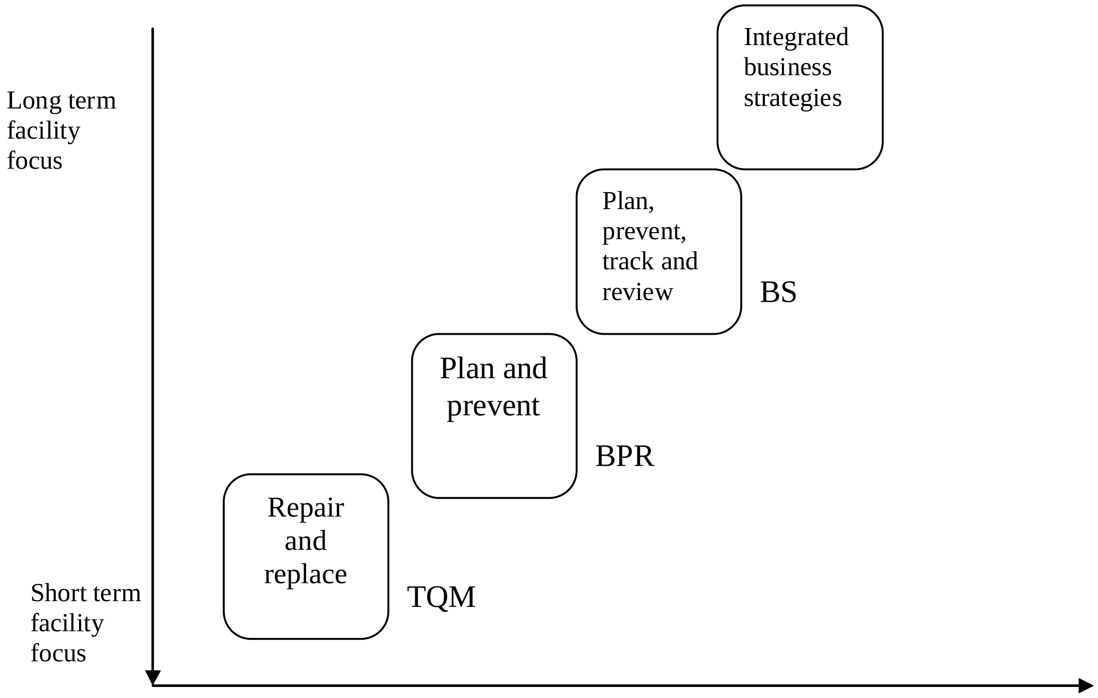

Figure 5.0: Focus and new business technology

5. Conceptual Framework

The overall conceptual framework that forms the basis of this pilot research project is shows at Figure 6.

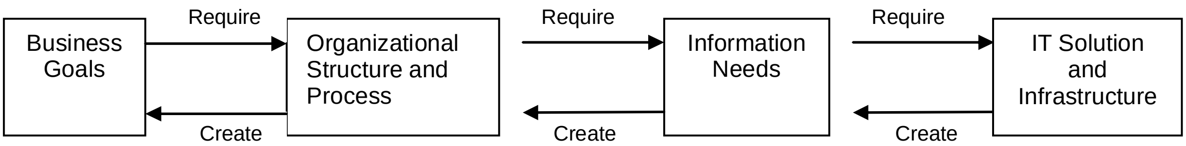

Figure 6 : Sample of Conceptual Framework

This conceptual model hyphenise that information technology acts as both amenable (provides new possibilities for organizations to achieve business goals) as well as a source of innovation (emerging technology provides new possibilities for organizational structure and processes and may generate new business goals)

In addition, this model may influence organizations in at least three different ways:

1. *Strategic positioning*

Information technology may provide a means for organizations to uniquely position themselves in the market place in a manner that would be impossible without the availability of information technology. Examples of strategic positioning are emerging in the form of 'virtual organizations' which provide substantially improved value to customers compared to traditional organizations. Strategic applications of information technology may involve inter-organizational information sharing, such as the use of distributed database.

2. *Work group productivity*

Instead of affecting the entire organization, work group productivity effect subsets of an organization. The use of groupware (e.g., Internet collaborative applications) has the potential to empower and integrate project teams for substantial improvements in project productivity and at the same time reduce the need for middle management.

3. *Process redesign*

Process redesign may affect the productivity of one or more individuals as jobs are reconfigured and processes simplified. Information technology can facilitate the task of process redesign by providing tools that eliminate routine jobs and decentralize decision-making.

6. Conclusions

In Malaysia, the facilities management concept is still relatively new concept. However, Centre of Excellence for Facilities Management, KUiTTHO is struggling to introduce this concept to government of Malaysia. Even tough this still new concepts, due to rapid development in ICT, FM in Malaysia also have to integrated with ICT. Strategies for use the ICT are not universal. Countries face different circumstances, priorities and financial means and should therefore adopt different strategies accordingly. The framework can be help in determining a strategy regardless of what goals have been established, since coordinated action along the five areas identified in the framework is always likely to yield more effective results. However, the evidence and analysis presented suggest that strategy that focuses its ICT interventions towards the achievement to development goals is more likely to achieve marked socioeconomic development. Facility management is essentially workplace management. In essence, it is a manifestation of facility management as the interface that manages changes in people, facilities and technology. They are many opportunities and expansion areas are it in properties, human resources, finance or ICT. Facilities management should have the ability to anticipate as to what organizations will require in future years. In the past, the role of facilities was merely that of service provider, and now, facilities management as business solutions. This paper hopefully can be a guideline for companies to implementing an ICT in their companies as well as facilities management concept especially in Malaysia.

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Integrating Building Performance Assessment Concepts in Shared Building Models

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Abstract

Traditional modeling efforts in AEC have generally focused on design descriptions. As a result they do not consider information on how settings perform during use in areas critical to building owners and users. The authors argue that integrating performance data in building models will greatly enhance the end-uses of conceptual modeling efforts in AEC in facility management and design evolution. The authors describe a modeling study that integrates descriptive and evaluative/ performance concepts in existing building models, and illustrate several end-use scenarios to support their assertion.

Keywords: Conceptual model, building performance, post-occupancy evaluation, building procurement.

1. Introduction

The lack of attention on the formal representation of data from building (facility) evaluations represents a missed opportunity in modeling efforts in AEC. Traditional modeling efforts were geared towards the ‘as-designed’ (‘as-designed’ as distinct from ‘as-used’ and ‘as-experienced’) environment to aid facility management. But are as-designed data sufficient? Can data from buildings-in-use potentially enhance end-use of building models? As-designed data pertains to data available up to the final stages of design development and specifications of a building. Such data relates to the properties and performance of the systems and sub-systems, and are based on existing knowledge on building physics and standard performance assessments in a-contextual settings, i.e. not specific to the context (social/ cultural/organizational setting) in which a building is situated. Typically the performance assessments are obtained from accepted building simulation practices that assume a “controlled environment with standard users” as the basis for the simulation.

The importance of context-specific data, from buildings-in-use, is beginning to get reflected in recent literature. For instance, Becker [1] advocates the necessity of data from buildings-in-use in the domain of material durability, and propounds the creation of predictive tools based on such data. Current building models, however, do not reflect the variations in usage pattern across setting types (from hospitals to schools, offices or courthouses) in buildings-in-use. The fact that such buildings-in-use data are becoming widely available brings this issue to an even sharper focus. Post-occupancy evaluations (POEs, or FPEs - Facility Performance Evaluations) are regularly conducted by large organizations with building portfolios. They are used not only in problem identification and modification in built settings, but also in informing portfolio management decisions. From a purely facility management viewpoint, buildings-in-use data could supplement existing data in two significant ways: 1) reduce uncertainties arising from simulations in controlled environments, and 2) reflect variances across setting/ occupancy types, and, thus, improve context specificity.

Performance can also be viewed beyond the performance of systems and sub-systems. Gross [2], for instance, underscores that users' requirements are not well understood at present. He emphasizes the variations that exist in culture, economic capabilities and expectations, and asserts that such human factors have not been accorded due importance in performance assessments, such as productivity in the workplace, health, and well being. POEs happen to address some or all of these issues. Integrating performance (POE) data with other descriptive data, thus, promises to enhance the end-use of building models in facility management, and possibly in design decision-making. POE and other descriptive data currently reside in disjoint representations and formats. This prohibits their integration in and joint use in decision making. The key question addressed in this paper is the need for a proper mechanism to capture rich facility evaluation data and integrate it with other building data in such a way that FM decision making is optimally informed.

2. Integrating Descriptive and POE Data

The investigators started off the study with two main questions: 1) can evaluation/ performance (more specifically, POE) data be meaningfully integrated with other descriptive (as-designed and as-built) data in a shared building model based on a unified conceptual building representation, and 2) if so, in what conceivable way could it expand the end-use of building models?

2.1 The Georgia Tech Study

This paper draws on a Georgia Tech modeling study that integrated as-built data and facility evaluation (POE) data in courtroom settings [3]. The study focused on courtrooms as setting types for several reasons. Courtrooms constitute setting types with a range of complex and conflicting functions, ranging from the instrumental (visual, auditory, and access) to more intangible symbolic functions (portraying the openness of the judiciary and authority of the State). Secondly, courtrooms are physically self-contained spaces, thus rendering the modeling effort relatively simple. Finally, the investigators had access to courtrooms and courtroom users (judges, deputies, reporters, attorneys, security staff, etc), courtesy of the CourtsWeb project at Georgia Tech.

2.2 Methodology

POE and descriptive data from 26 courtrooms in 16 courthouses were used in the model. The data included 43 descriptive and technical performance measures (lighting, thermal, acoustical, physical/ spatial configuration, etc.), 27 evaluation measures (users' evaluation of the supportiveness of their work setting for instrumental and symbolic functions), and, finally, six personal/ cultural measures (users' role, age, gender, etc.). A conceptual model integrating the different types of data was developed using EXPRESS-G [4]. The presented schemas of the model, for the purpose of this study, should be viewed as an aspect model [4] that would go through an integration cycle to be finally integrated with a comprehensive and complete building model such as the IAI-IFC [5]. Schemas of the aspect model were translated into database schemas and were instantiated with the data collected in the POE studies. A range of queries was implemented to assess its meaningfulness in supporting various end-use scenarios. Important modeling aspects such as extensibility, IFC integration, and others were not considered at this stage of the research as the emphasis was on the feasibility and adequateness of the proposed semantic integration of POE and other descriptive building data.

3. The Data Model

The primary focus of the modeling effort was in integrating data pertaining to the physical envelope, functions of settings defined by the envelope, evaluation/ performance data of such settings in use, and finally the attributes of the users using the built settings (figure 1 articulates the fundamental direction of this inquiry).

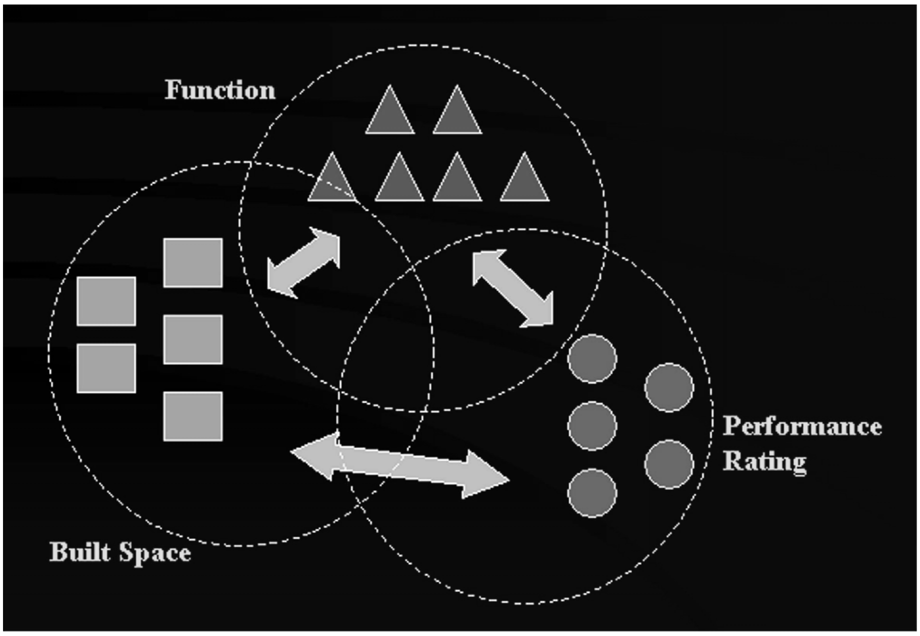


Figure 1: The key modeling concept involved the integration of as-built data with data pertaining to functions and performance.

Figure 2 shows a stripped-down model with entities alone (without the attributes) to provide a birds eye view of the relationship structure. The central concept of the model is 'space' The model can be viewed as four chunks of data, linked through the entity 'space': 1) identifiers that hold data that would enable identification of a particular site, project, building, and floor, 2) the enclosure system, 3) various functional areas within an enclosure system, and finally 4) evaluation data from POE studies.

Owing to paucity of space detailed schemas on the first two data chunks are not included in this paper, which are conceptually similar to the corresponding parts of the IAI-IFC. Data on site, building and floor are essentially used as higher-level identifiers and classifiers, such as city, state, jurisdiction, and building type. Schemas on the enclosure system are designed to hold as-built and as-designed data on elements that physically define (enclose) the courtrooms. Such elements include the walls, floor, ceiling, and the services support systems. The remaining model is described below.

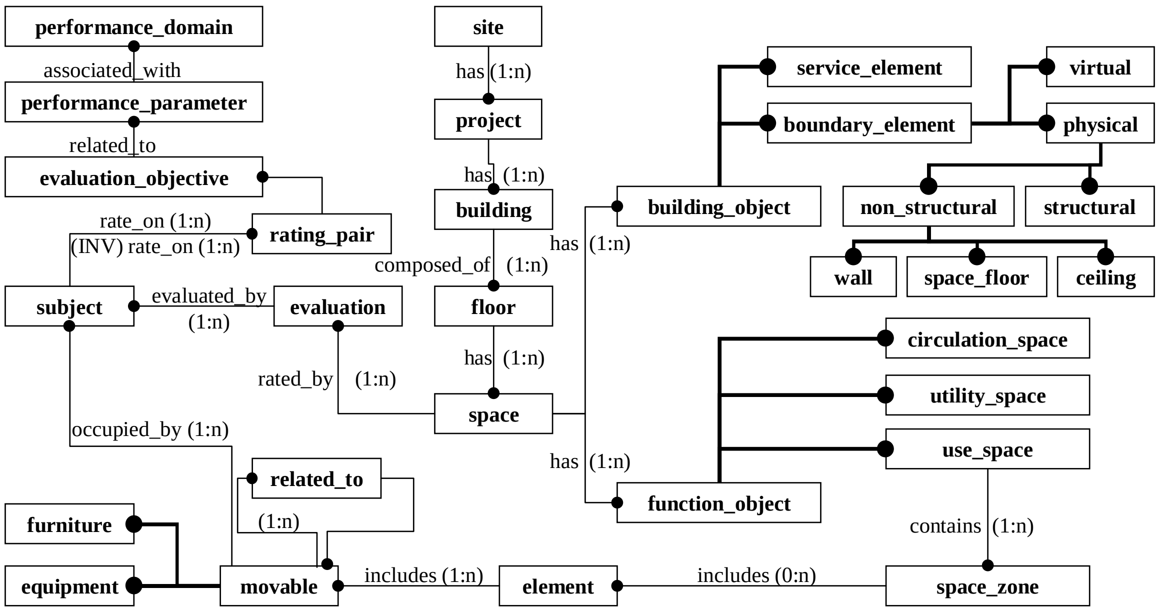


Figure 2: The model (without the attributes) showing the basic relationship structure.

3.1 Functional Entities

Functional entities hold data on spatial functions and sub-functions physically enclosed by the enclosure systems. The schema captures the major (higher level) functions, various sub-functions or functional zones that organizationally cluster together to define a functional unit, key elements within the functional zones, and movables (furniture and equipments) within the key elements. Relationships of interest between each pair of movables are included, such as the distance between elements or the level difference. At the highest level, each function type is described as a *function_object*. For simplicity sake, the *function_object* types have been defined as *use_space*, *circulation_space*, and *utility_space* (figure 3), while it is appreciated that various combinations of these function types are also possible. Each use space is identified by a *use_category* and a *use_type*. Use category refers to the primary function of the use space, such as ‘courtroom’. Use type provides further information by stating the particular subtype of the primary function, as in ‘magistrate judge’ (courtroom). Each use space could be host to one or more space zones (*space_zone*). These are more specialized functions conducted within a larger functional unit, for instance, courtroom “well” (the part of the courtroom where all trial

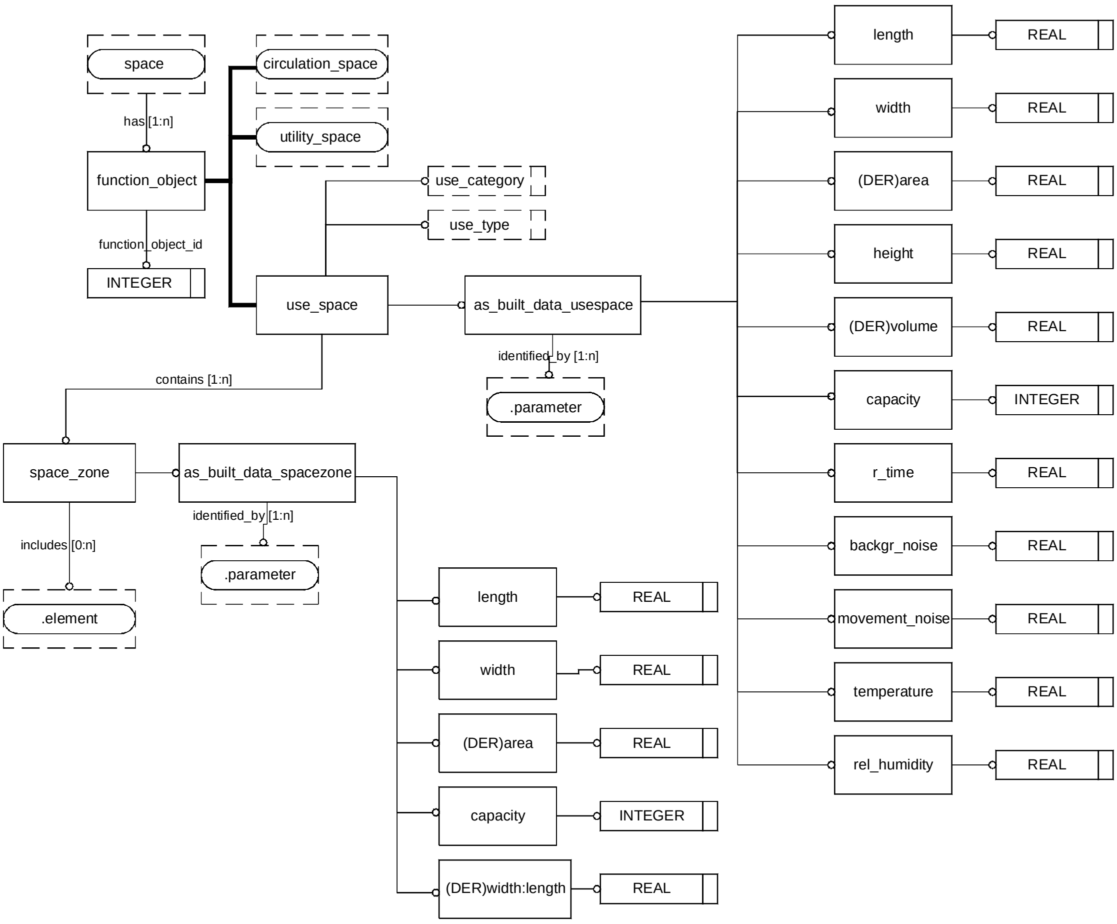
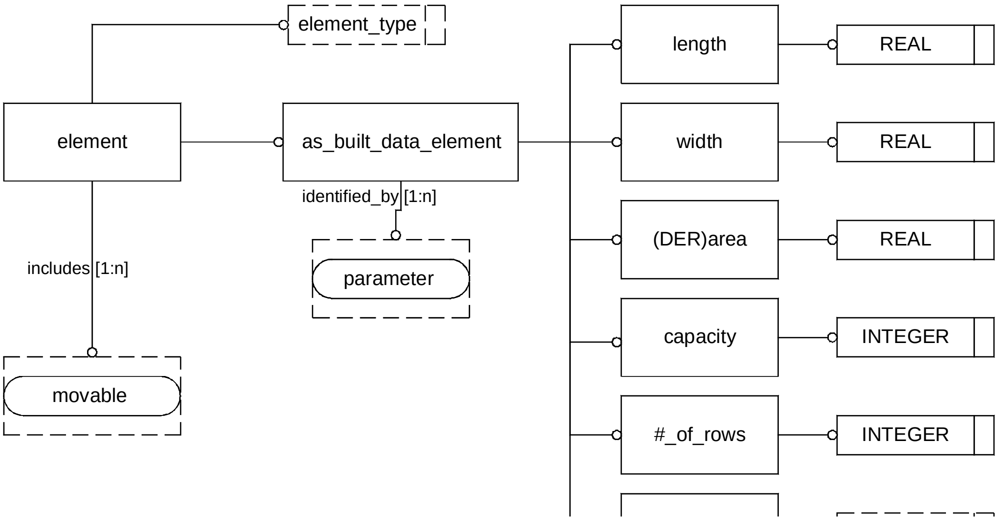


Figure 3: Use space and space zone as function entities.

Within each space zone there can be none or more elements (element). Elements are base-level specialized functional units where very specific functions are performed. In a courtroom well, the elements include the bench, the reporter station, the deputy/clerk’s station, the security personnel station, the attorney area, the jury box, and the witness stand. Similarly, courtroom galleries have spectator seats. Figure 4 illustrates the element schema.



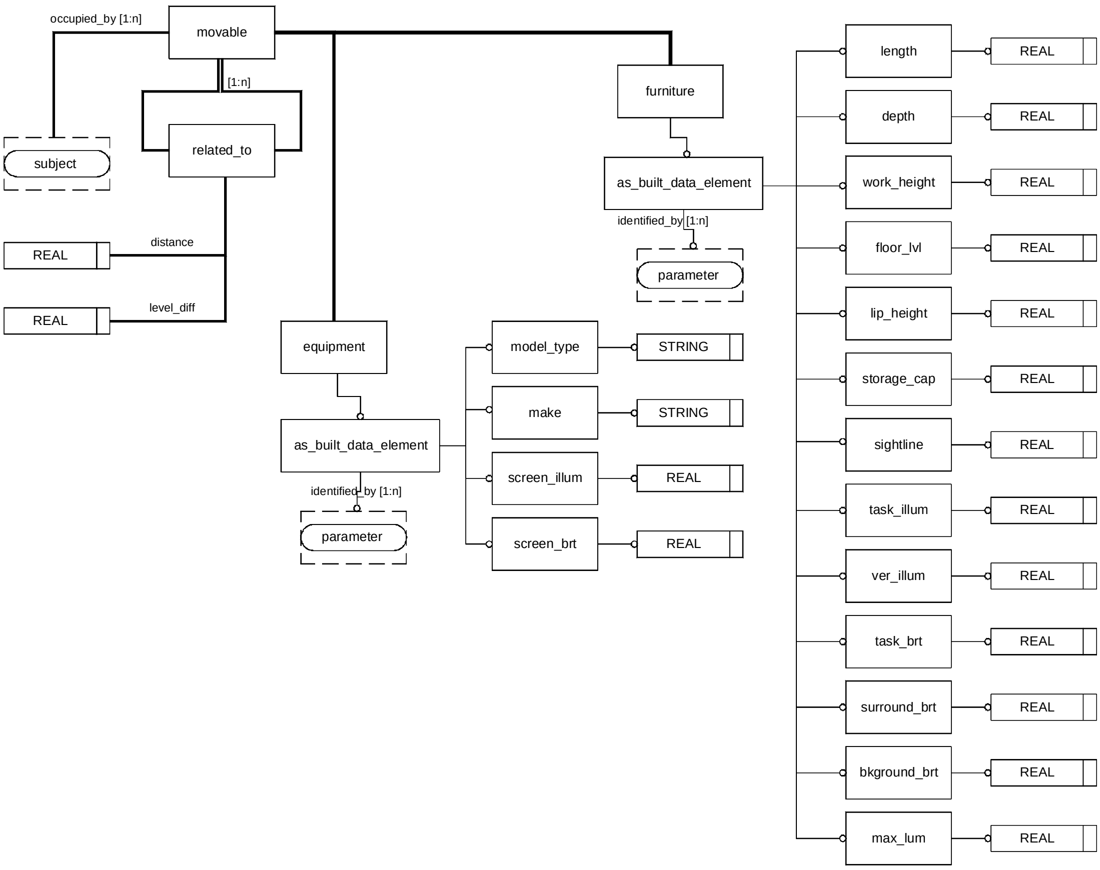


Figure 5: The movable schema.

Each element in a space zone includes one or more movables (*movable*). For instance, the reporter's station typically has only one piece of furniture (movable) where as a jury box can have as many as 21 or more piece of furniture. Movables are essentially *furniture* and *equipment* associated with a particular element, with base-level specialized functions (figure 5). Relationships between movables are some key areas of interest. For instance, the *distance* between each pair of movable in a courtroom well (witness to judge, for instance) influences the clarity of observing witness testimony. Similarly, the level difference (*level_diff*) between each pair of movable in a courtroom influences the lines of sight as well as the symbolic rendition of the courtroom.

3.2 User and POE data

The remainder of the model pertains to performance/ evaluation data. Data on performance issues/ dimensions and users constitute the main focus of these schemas. Evaluation of settings could be conducted on several issues or performance dimensions (this model is limited to issues specific to courtrooms, but expansion to other issues is straightforward). A classification structure for the issues, based on literature, is created to ensure better comprehensiveness of the data structure. Figure 6 shows the schema on user and performance/ evaluation data.

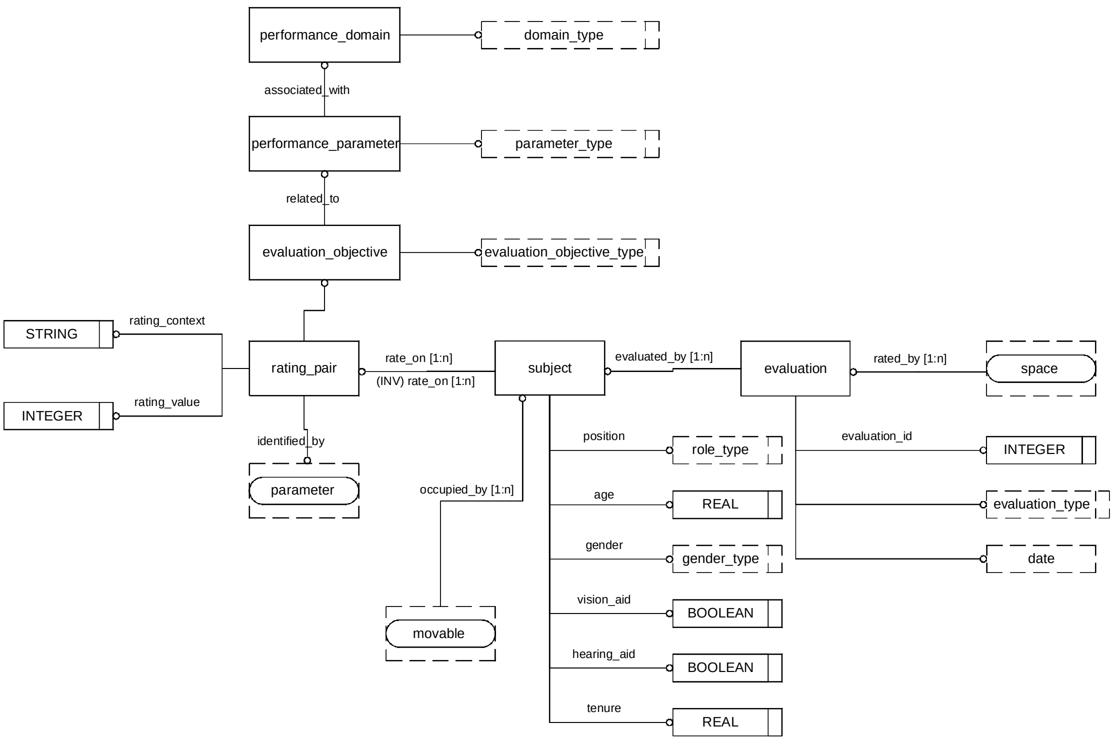


Figure 6: Schema representing data related to user and POE.

One or more users (a more generic term *subject* is used in the model) occupy each movable. The type of POE considered in this study is one where users of buildings-in-use evaluate their setting on an assigned scale. As a result, each instance of evaluation data is associated with a specific user who, in turn, is associated with a particular movable in an as-built setting. Further, POEs target one or more spaces in a facility, and each space is rated by one or more evaluation studies (*evaluation*). Each evaluation has an associated *date*, and an *evaluation_type* (POE, in this study). Typical POE studies collect various kinds of demographic data from the participants/subjects. In this study six types of data were collected. User *role_type* pertains to their position in the organization, for instance judge, reporter, and deputy/clerk. The data types *age* and *gender_type* are self explanatory. User *tenure* relates to the number of years the user has worked in the current position, which bears psychological connotations on evaluation data. Data on *vision_aid* and *hearing_aid* are yes/no Boolean data types that provide information on whether the user relies on the aid of hearing or visual devices for performing standard tasks in the courtroom. Evaluation data are captured in the element *rating_pair* where *rating_context* describes the context of evaluation (or the specific thing being evaluated) and *rating_value* is the actual numeric rating.

Rating pairs are classified based on knowledge from existing literature - the entities *evaluation_objective*, *performance_parameter*, and *performance_domain* provide the framework for classification. Gifford [6], for instance, lists performance, feelings, and stress as some key objective (outcome) areas in studies on office settings. Many POEs include user preference and productivity as study objectives. The objective associated with a rating pair determines the evaluation objective of that particular rating pair. Further sub-classification of evaluation data into parameters and domains is also supported by literature. For instance, Gifford [6] contends, “the work environment can be considered not only as a collection of physical stimuli (noise, light, temperature, etc.), but also as a physical structure (size, furniture, hallways, etc) and as a symbolic artifact” (p.340). The segregation of data into environmental (‘physical stimuli’) and physical (‘physical structure’) provides a meaningful classification structure that corresponds well with established classification structure in literature.

4. Outcomes

A database was generated according to the schemas of the previous section and filled with data from courtroom and POEs conducted in those courtrooms. The database was used to assess if and how the integrated information augments/ informs decision making in facility management and design decision-making. It is expected that the addition of evaluation/ performance data opens up potential end-use opportunities in at least four different areas: 1) monitor facilities, 2) identify best practices, 3) manage building portfolios, and 4) inform design evolution.

4.1 Monitor Facilities

As asserted earlier, in the absence of performance data one could predict performance of building systems based on standard simulations in a-contextual settings. Integration of evaluation data from buildings-in-use adds specificity to monitoring everyday performance. Moreover, facilities could be monitored in their supportiveness to the functions performed in the built settings, in addition to the performance of systems and sub-systems. In courtrooms, for instance, regular organizational POEs could inform courthouse building managers about how well the courtrooms support the major tasks/ functions conducted within it, which may change over time owing to physical and/or personal/ cultural/ organizational factors. A specific example will help illustrate this end-use scenario. Consider, for instance, a simple example of reading task in courtrooms (reading from legal documents, exhibits, etc.). Existing literature takes into account various factors to predict lighting conditions for certain reading tasks. Such predictions are generic, and applicable across setting types. The POE data augments such information is in two ways. First, it provides evaluation data from actual settings-in-use, and is specific to a context type (in this example, courtrooms). Second, it brings into consideration other personal and cultural factors that are not considered in lighting models. Thus, the data extracted pertains to specific areas in a building, dealing with a specific set of users, with known user characteristics (collected through POEs). Such specificity of information supplements the generalized prediction models in lighting. A more compelling factor is one of human psychology. Referred to as the 'halo effect' in psychological literature, users of built settings tend to consider newer settings more supportive irrespective of actual performance of settings. Such factors are reflected in POE data. The contextualized, specific, evaluation data would enable facility managers to monitor facilities in a more efficient way. Table 1 shows an example where the users' ratings of the supportiveness of the courtroom (on a scale ranging from 1 = very unsupportive to 7 = very supportive) for reading task, along with lighting data, are extracted from the database. In a similar manner, other important functional aspects of built settings could be monitored on a regular basis to identify areas that need improvement.

Table1: Query result showing users' evaluation of the supportiveness of the courtroom for reading task, in Clarke County Courthouse, and data on a sample set of lighting parameters.

building_name	work_plane_illuminance	vertical_illuminance	task_brightness	surround_brightness	background_brightness	user_role	rating_context_type	rating
Clarke County	155.3	94.1	482.4	79.17	165.1	judge	reading task	7
Clarke County	64.8	25.1	191.6	79.17	80.91	deputy	reading task	7
Clarke County	64.8	25.1	191.6	79.17	80.91	deputy	reading task	6
Clarke County	76.4	22.2	236.1	79.17	84.01	reporter	reading task	7
Clarke County	84.9	33	241.7	12.96	75.38	attorney	reading task	7
Clarke County	84.9	33	241.7	12.96	75.38	attorney	reading task	7

4.2 Identify Best Practices

While monitoring settings for improving context-specific performance, facility management could gain from knowledge on best practices in similar settings. Such information could enable the facility managers to arrive at improvement options that predict most favorable outcomes. Consider for instance, in case of a certain courtroom, a facility manager finds low evaluation rating from courtroom users, in the setting's supportiveness to reading tasks (same example as above). Querying the database enables extraction of data that shows the values of environmental parameters that could predict favorable evaluation. For instance, an end-user might wish to focus exclusively on best practices in illuminance for reading tasks (performance rating > 5) in Superior Courts Courtrooms. The outcome (figure 7) shows the proportion of users within each interval of illuminance level, across all courtrooms, that have rated a particular illuminance level above 5 for reading task support. It looks plausible from the chart that the best possibilities of favorable evaluation are associated with illuminance between 30 and 65 FTC. Since these evaluations are not immune to personal and organizational factors, they could vary from lighting guidelines and could vary across setting (building) type. The context-specificity of the information generated promises supplemental information support over traditional information available to stakeholders in facility management. Further, similar routines could be used to assess other environmental parameters in built settings.

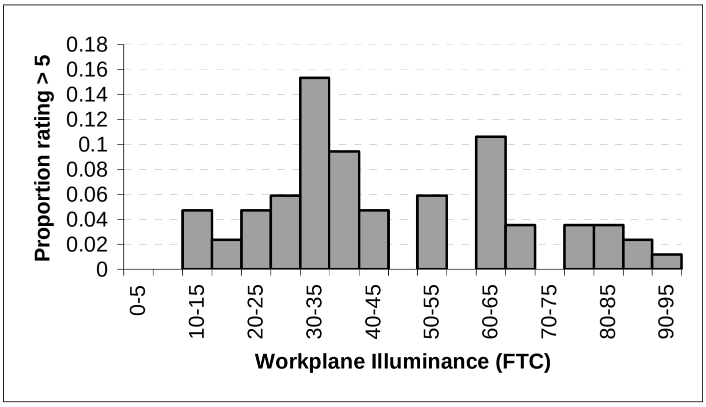


Figure 7: Chart generated from query showing the percentage of users rating their environment greater than 5 for reading tasks, within each interval of illuminance level.

4.3 Manage Building Portfolio

Regular POEs conducted in large organizations with building portfolios (such as US GSA, US Courts, USPS, etc.), that would enable the scenarios discussed in 4.1 and 4.2, would also aid in managing building portfolios. Since the evaluation data obtained in the example cited in this paper pertains to the functions carried out in a setting, longitudinal assessment of the data would provide visual as well as numerical feedback on the extent to which different facilities are supporting the functions they are designed for. The fact that the evaluation data captures psychological factors, such as the halo effect, contributes more utility to the feedback, since reduction in perceived supportiveness of settings to the functions conducted (irrespective of actual performance of settings) could contribute negatively to organizational objectives. Data on actual technical performance, as well as assessment of supportiveness by users, together, in longitudinal assessments, would provide information not only on the projected performance of systems but also on when users of settings could be expected to perceive their environment as unsupportive.

4.4 Inform Design Evolution

Many of the features described above bear potential to inform design evolution phases of facility procurement. Existing literature on the design process by Zeisel [7], Lang [8], and Kalay [9] articulates at least five end-use scenarios where the integration effort could inform decision-making: 1) case exploration, 2) precedence analysis, 3) identifying best and worst cases, 4) rating design decisions, and 5) predicting performance. The same features that aid in monitoring facilities support case exploration and precedence analyses. Similarly, identifying best practices is not only informative for facility management but also to design decision-making (owing to paucity of space only a few scenarios are described here; more scenarios and details are included in Pati 2004).

5. Conclusions

While the possible scenarios of end-uses could be many, the few illustrated above exemplifies how integrating evaluation/ performance data with traditional building models could provide (augment) meaningful services in facility/ portfolio management, and expand the utility of the modeling efforts to end-uses in design evolution. This begins to address needs expressed not only in the domain of building engineering, but also in the field of Environ-Behavior studies, where interfacing building research with design practice constitutes one of the primary objectives.

Although this study focused on just courtrooms as built settings, it can be asserted that the direction of inquiry could also fit other setting types. For instance, it could be argued that issues and classification structure developed in this model also hold true in (or can be expanded to include) office settings. Privacy, stress and many other issues seem to be common to offices and courtrooms. Similarly, relationships between movables (distance, elevation, angular dimension) are probably also important in office settings. Literature survey conducted for this study suggests that offices, schools and courtrooms share many of the issues included in this study. The definition of the elements and attributes in this model reflects possible generality to offices and schools, although expandability of the model to other setting types remains a question for further academic inquiry. Despite the limitations, the outcomes of this study suggest a robust and potent direction of inquiry for modeling efforts in AEC, leading to extensions of comprehensive building models such as the IAI-IFC.

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Development and Implementation of an Open Source Software FM-System

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Abstract

Bergen Bolig og Byfornyelse KF (BBB) – a public housing company comprising 5000 dwellings – has been looking into the possibility to utilize some of the vast pool of open source software for maximal flexibility and minimized costs of tailoring a fm-system to its needs. This work has been undertaken as part of a phd thesis at the Norwegian University of Science and Technology by the same author as this paper.

The objective of this work has been to reduce license costs of software, improve the flexibility of software development, improve the information flow, to improve the quality of data (centralized documentation and history), to lower the general threshold for implementing a fm-system and to reduce manual handling of invoices through utilizing principle of e-commerce by the use and development / adaptation of open source software.

Keywords: Open source software, FM-system, web, php, e-commerce

1. Open source software

Open Source Software is not only about free software – but an important concept within decentralized software development founded on knowledge, idealism, interest, anti authoritarian rebellions and the communication power of the internet.

"It gives customers control over the technology they use instead of enabling the vendors to control their customers through restricting access to the code behind the technologies." [1]

Free Software Foundation (FSF) was founded in 1985 by Richard Stallman – and is dedicated to encouraging users to use, study, copy, modify and redistribute software.

The definition of free software is defined by [2]:

- The freedom to run the program, for any purpose.
- The freedom to study how the program works, and adapt it to your needs. Access to the source code is a precondition for this.
- The freedom to redistribute copies so you can help your neighbor.

- The freedom to improve the program, and release your improvements to the public, so that the whole community benefits. Access to the source code is a precondition for this.

1.1 A Hacker's Motivation / Ideology

Two degrees of variation [3] seems to describe the motivation and ideology for a typical hacker:

1. Zealotry; enthusiasm regarding open source software in itself.

2. Hostility to commercial software.

The most visible and best organized part of the hacker culture – represented by FSF - has been both very enthusiastic and very anti commercial. After the Linux explosion of early 1993-1994 the culture has moved towards the pragmatic end.

In addition to the ideology there are motivations like "ego-boosting" (status in the hacker culture) and that it is fun and intellectually stimulating to participate.

2. The Software Project

The project started out as an attempt to simplify the maintenance management provided by a commercial fm-system – which at the time seemed to be a very complex – and to some extent – rigid environment. One other motivation was the high costs related to customizing – and the fact that all customization was depended on the vendor.

In the search for an appropriate platform - an Open Source project came to attention that had some interesting capabilities which could serve as a base for development.

Since this project provided a high level free entrance to an appropriate system – it is also fair that the work based on this project should be free.

2.1 PhpGroupWare

phpGroupWare - is a multi-user groupware suite written in PHP that provides about 50 web-based applications, as there are the Calendar, Addressbook, an advanced Projects manager, Todo List, Notes, Email, Newsgroup- and Headlines Reader, a Filemanager and many more Applications.

The system supports user preferences, themes, user permissions, multi-language support and user groups. It includes modules to setup and administrate the working environment. The groupware suite is based on an advanced Application Programming Interface (API).

There are currently about 25 active developers/contributors.

The project is hosted at savanna.gnu.org which is a central point for development, distribution and maintenance of GNU Software.

2.2 Property – A FM System

Property is the name of the FM-module of phpgroupware. It started out as a rewrite of the project module – where the most significant change was the change in perspective from vendor to buyer – and the introduction of a location hierarchy. Later on it has evolved as a fullblown maintenance / project management system with e-commerce and documentation capabilities.

2.2.1 Model - Context

To place this software in its right context – it is useful to locate a spot for it in an information system model.

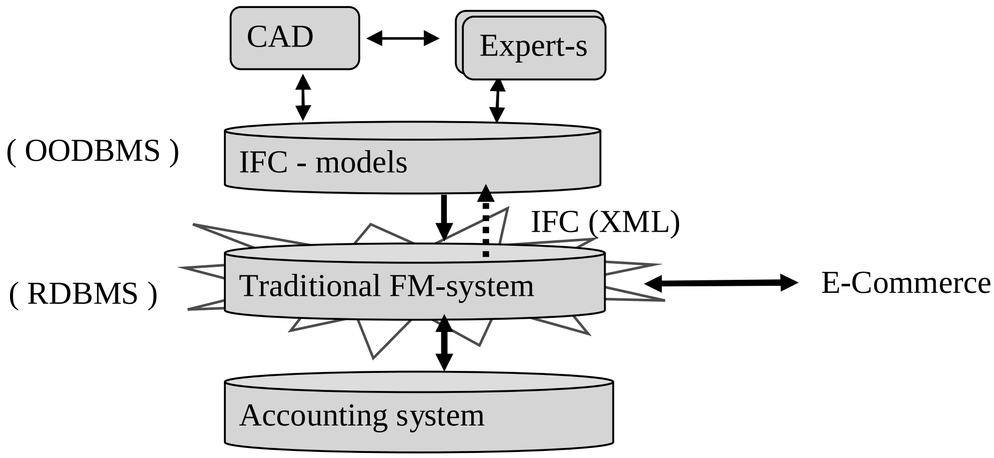

Figure 1FM-system related to IFC

It is the author's opinion that the introduction of IFC-models [4] not for many years will become a common platform for operation phase data handling due to the costs related to converting existing models to IFC. In addition – as IFC is based on an Object Oriented Database management system – performance (speed) – might be an issue. This leads to the assumption of the need for a RDBMS FM-system that is fed by relevant data from the IFC-model where this is possible.

2.2.2 Technology / Principle

There are some fundamental blocks to relay on: A database, a script interpreter and a web server. This kind of technology is often described as a 3-tier architecture [5] – which means that the system is separated into a client-tier, an application-server-tier and a data server tier. The client tier is in this case a standard web-browser, the application server tier is the collection of scripts used by the web server and the dataserver tier is the databaseserver.

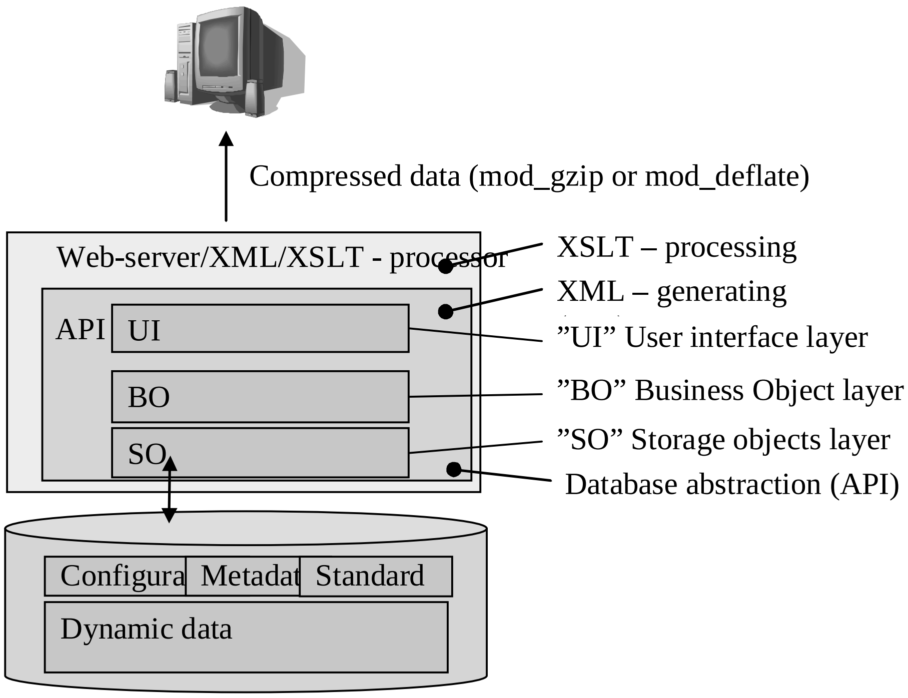

Figure 2 Principle technology

The middle –tier is the actual “program” – representing the logic operating on the data. This tier is also separated into a common API for the whole project – and a set of layers within each module which represents a typical responsibility.

The output from the UI-objects is an array – which is converted into XML and fed into a set of XSL-stylesheets for processing to XHTML.

2.2.3 Architecture

The database is in general built on some fundamentals as locations, physical objects, documents, actors, their conditions, relations and operations:

- *Locations* – is organized in a highly customizable hierarchy
- *Entities* - is a generic class of objects, that can be defined as reports, equipment and so on - which can be linked to locations or other entities
- Actors
- Tenants/User of location
- Vendors
- Owners
- Operation/events
- Request for action of any kind
- Workorders - organized into projects

- Service agreements
- Payments/Cashflow

2.2.4 Meta-database

Certain elements in the application as location, service agreements, entities, actors, are organized in a meta-database which contains information of tables, columns, relations and attributes.

The database queries and name of columns to return (visible and hidden) is dynamically created on the fly the first time - and stored in a cache table (fm_cache) for later use to save processing overhead.

2.2.5 Location

"Location" is a physical part of the property - and it is common to organize the locations in a hierarchical structure with "part-of" relations

- Name Level
- -- Property 1
- /-- Building 2
- /-- Entrance 3
- /-- Apartment 4
- /-- Room 5

Example 1: location hierarchy

The hierarchy is configurable in both width and depth - that is: one can define as many levels as one like - and each level can also have as many attributes as one would like

- Name Level Relation
- -- Property 1 <--- Owner,part of town
- /-- Building 2
- /-- Entrance 3 <--- Street
- /-- Apartment 4 <--- Tenant
- /-- Room 5

Example 2: location hierarchy with configurable external relations

Each level has a primary key - composed by the foreign key to the parent - and this levels ID. In addition - there is a "superkey" named *location_code* for indexing and searching across the hierarchy

location_code	loc1	loc2	loc3	loc4
5000-01-01-001	5000	01	01	001

Example 3: part of the table location4

- Primary key: loc1 + loc2 + loc3 + loc4
- Foreign key: loc1 + loc2 + loc3
- Superkey : Location_code

Example 4: keys for level 4: Apartment

When querying location on a certain level - it is joined with all its ancestors to make inherited information available.

2.2.6 Entities

Entities is a generic class of objects that all have in common that they can be placed in a location and/or linked to other (only one) entities.

Entities are organized in class of entitity and entity category: each entity_category is represented by their own table:

- Equipment
- Elevator
- Fire alarm central
- Cable TV
- Building components
- Reports
- Condition report
- Insurance damage
- Elevator control report

Example 5: Structure of entities at the BBB implementation

Reports are configured to be linked to both Equipment and location — that is: One can write reports on both Equipment and location.

The table representing the category elevator in the entity-class Equipment is here named fm_entity_1_1

Information about the different attributes and their datatypes is held by the metadatabase

2.2.7 Projects

A project is a collection of orders/contracts. The project is linked to a location or entity_category (equipment). Projects are separated in orders/contracts that could be subject to bidding contest amongst vendors. Each order is linked to its parent project and to a vendor - and consists of a series of work-descriptions to perform and / or items to deliver.

An order can be defined as simple as a brief description of simple tasks - or as a detailed complex tender document with a full blown deviation auditing system per record in the contract.

The perspective of the projects is from the receiver of the product delivered.

2.2.8 Helpdesk

The HelpDesk submodule is a hacked version of the phpgroupware's standard Trouble Ticket System application (TTS). The main differences is that the tickets are fixed to a location or entity_category - and that one is able to start projects and entities (i.e. reports) from a ticket - which enhance the trace-ability

The owner of a ticket is notified by mail when the ticket is updated if the user doesn't choose not to.

2.2.9 Invoice Handling

A very important feature is the ability to interact with accounting systems. The invoices are imported into the system by fileformat agreed upon by the vendors – granted for payment by users based on roles – and then exported to the accounting system for payment. Both import and export filters are very easy to adapt to the current implementation – and appear as independent drop in filters.

2.2.10 Alarm Handling

It is possible to notify alarms on timers as email – along with any other predefined task. This is accomplished by a cron job that checks if there is something scheduled.

2.2.11 Documents – File Handling

Drawings, pictures, signed contracts is examples of documents that is handled by the vfs – virtual file system. This enables any type of file to be uploaded as attachment to a range of elements in the system.

2.3 Development

The work on the system has been done in very close cooperation with the organization in a dynamic process with the users as a very important source for demands, feedback and bug testing. There is a set of roles and their needs to satisfy related to the topography of the organization and the surrounding systems which it interacts with.

The work has derived advantage from the open source community as it has been designed as an add-on module to the open source project phpgroupware – and has had access to their development resources and a handful of very skilled programmers.

The source code is stored into the main phpgroupware project at http://savannah.gnu.org – using cvs (Concurrent Versions System) - which allows the project member to revise the code and collaborate on joint development.

The property module is developed at BBB – and implemented gradually as it has evolved. The first feature implemented was the ability to place a simple workorder – linked to a location. In the beginning this system overlapped with the former system in that way that it also wrote a copy of the order to the former system. This strategy made it possible to go back if it turned out to be a bad solution.

The system has been developed on a dualboot windowsXP/Linux laptop – that is – written on Windows and tested on Linux.

The actual data stored in the database-backend is organized as a well normalized relation database – which makes it an easy task to convert data from or to other FM-systems. The logic operating on the data is located as the middle tier in a three-tier architecture implemented on a centralized web-server which simplifies the administration and maintenance of the software as no client installation is needed.

All files have been saved to the cvs-server at savannah.gnu.org – this enables in theory simultaneous remote collaboration by many parties in addition to enable a view of historical changes. The cvs-server allows parallel versions to live together (branches). The idea is to have a stable release where only bugfixes is performed – and one (or several) development branches where new features and ideas is tested.

Savannah also provides some other useful collaboration tools:

- Several informal mailing lists (for users and developers) where questions and opinions are posted.
- A helpdesk in four categories where items are assigned to part of the system and a developer:
  - Support – user questions
  - Bugs – for registering errors found in the software

- Patches – fixes and codesnips prepared for reviewing.
- Requests – feature request for the next release

3. Sample Implementation at BBB

Phpgroupware with the application property is implemented as part of the total FM-system at Bergen Bolig og Byfornyelse KF (BBB) – integrated with a tenant / lease administration system and the company's accounting system.

The webserver is a linux box based on a Mandrake 10.1 distribution which communicates with a database server (MSSQL) and a fileserver (Windows 2000).

So far 25000 orders are served by the system.

3.1 About BBB

BBB is a public housing company comprising 5000 dwellings located at the city of Bergen, Norway.

BBB has about 40 employees organized in a central head quarter in downtown and three satellite offices. All employees have access to both intranet and the Internet.

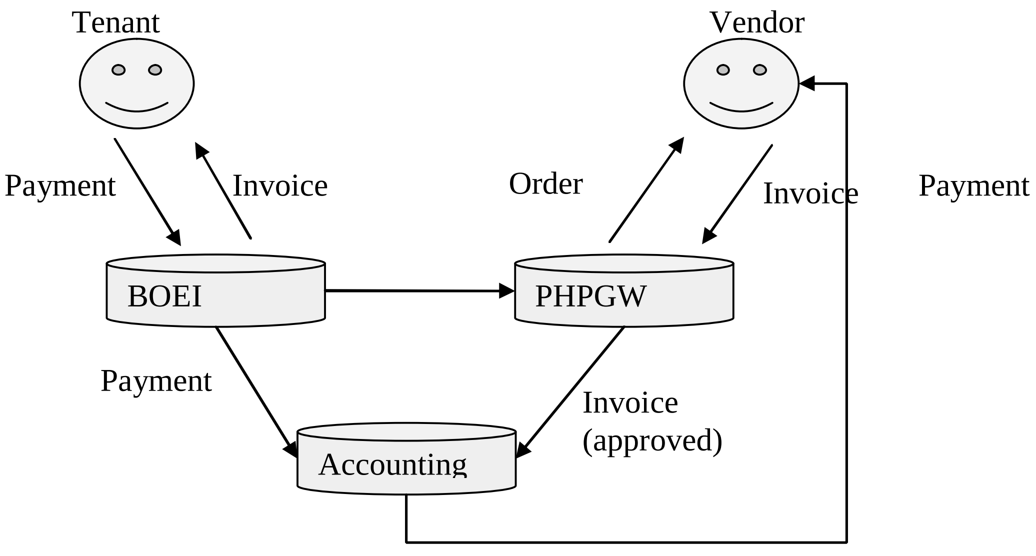

Figure 3Integrated systems at BBB

3.2 Integration

The location hierarchy and tenant information is "owned" by the tenant lease system (BOEI) – that is – all such information are originated in BOEI – and automatically transferred (or updated) to phpgw. The initial integration was implemented as two databases at the same database server (mssql) – and the synchronization was performed as scheduled jobs by executing stored procedures. Later – the database for phpgw was transferred to the linux server at a postgresql database. This was decided due to a 5 times gain in speed.

Now the synchronization is kept in order by a shadow set of synchronization tables at the originator database server to identify changes to transfer. The jobs are run as cron-jobs from the linux server via php-scripts that connect to phpgw_postgres and phpgw_mssql. To perform the actual comparison one need the master-tables from BOEI_mssql – and these tables are mapped as views in phpgw_mssql.

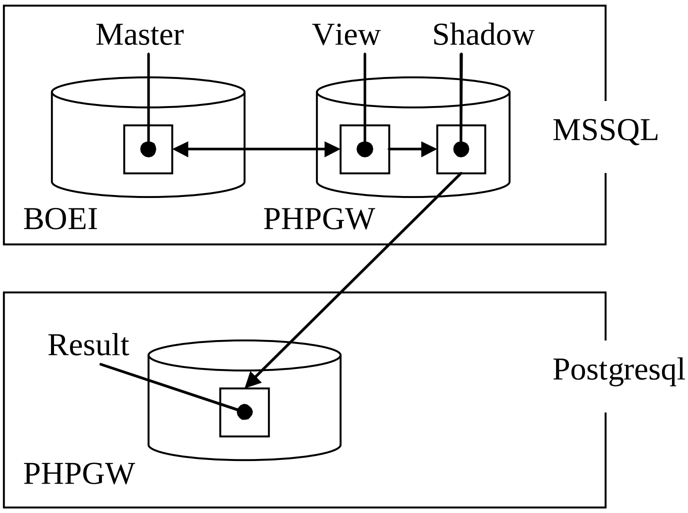

Figure 4 Synchronization model

3.2.1 Accounting System

Orders are sent by email to the vendors – which return the invoices at a monthly basis – and imported into the system for approval. Both approved and not approved invoices are exported to the accounting system to reflect the total claim for payment. During the import – the invoices are assigned to a supervisor and a budget responsible which both have to approve the invoice for payment.

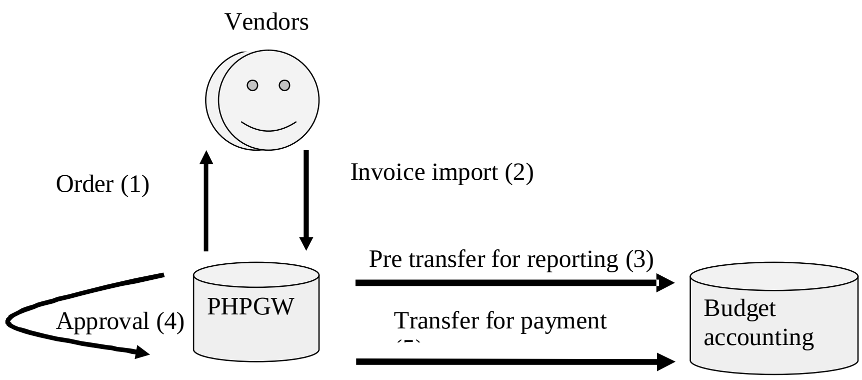

Figure 5 Dataflow –order/ invoice

Export:

The invoices are exported to the accounting system at a remote ftp-server as a set of files - and a backup-file is kept locally as reference. In case of error during import to the budget accounting system – the error is reported back – and a rollback is performed in order to correct the error.

4. Conclusions

The open source fm-system built upon phpgroupware has proven very successful – and has replaced commercial fm-system previously implemented in the organization. The system is very flexible as the organizing of locations and components are modeled in a metadatabase. The system is also integrated with the municipal accounting system as an automated e-commerce solution which greatly has reduced manual handling of orders and invoices – and increased the quality of control, workflow and the ability to do historical analysis.

The system is very adaptable and integration-friendly, given a certain general competence on programming database- and web-technology.

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Section III

Use of Product Models in Construction

The Use of Product Model Data in Building Construction Process

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Abstract

For the different parties of a building construction project, product modelling is an efficient data management method. Product model based data can be utilised and exchanged in various ways in and between different sectors of design, construction site management, and product industry. The product models of the different parties in a construction project can be integrated into a shared model which is augmented with data as the project progresses. In designing, both common product libraries and company-specific product libraries are used, enabling the transfer of product data from design to manufacturing. Creating guidelines for architectural, structural and HVAC design is necessary in order to make sure that data is stored in a concise way and that each designer can make use of the other designers' plans. In addition to design guidelines, another important prerequisite for this is IFC, a data transmission standard that allows information to be trustworthily stored and transferred between different software. Product model based construction process has been tested in several pilot projects where the results have been promising. Developing common principles and operating methods further will speed up and streamline product modelling in the building construction industry. As a whole, a product model -based process will improve companies' customer service, productivity, and construction quality.

Keywords: product model, data transfer, product component libraries, IFC data transmission standard

1. Introduction

During years 2003 and 2004, the Finnish construction industry has developed design, construction and maintenance in the building construction process based on product modelling. The development has taken place within the framework of a technology project called Pro IT –

Product Model Data in the Construction Process, in which businesses, research organizations, governmental organizations as well as interest organizations have participated. More information on this technology project can be found in a recent article [1].

A product model means a description of the building in such a way that, in addition to the geometrical 3-D visualisation, the model contains data defining the building and its components. The data may apply for example to the finishing structures in spaces, the characteristics of the materials, fire-resistance, colours, environmental impacts or sound insulation.

A product model is composed of product components, which can be modelled either on a case-by-case basis or by using ready-made product component descriptions in a product library. A product library is a collection of product components in an electronic form. The libraries contain the components commonly used in design, such as walls, doors and windows. It is also possible to make libraries of other product components, such as furniture and interior design accessories.

In the Pro IT project, a standardised method is developed for the design of a product model in the stages of architectural, structural and HVAC design. The starting point in the different design stages is the model created by an architect. The data exchange between the parties is developed on the basis of the international Industry Foundation Classes standard (henceforth referred to by the abbreviation IFC [2]). The main advantage of the IFC standard is that a number of designers from different fields can take part in construction projects irrespective of the software and file formats they use.

In construction industry, product modelling is still a relatively young technology and is not in widespread use. Despite the shortage of published information on or studies about practical applications and working methods of product modelling, there are some pilot projects on which the method has been tested with good results.

This paper proceeds as follows. In section 2, the benefits of the construction process based on product modelling as opposed to traditional processes are described, before the new process is briefly summarized. Subsequently, the need for developing general guidelines for product modelling designers is established in section 3, and the existing design guidelines as well as those still under development are described. Section 4 examines the IFC data transmission standard which is essential for the practical exploitation of product modelling, and section 5 casts a brief look into the different product libraries currently being developed. Section 6 sheds light on the pilot testing of the project. Finally, the conclusion summarises the essential points about product modelling and sets some directions for future development of the method in construction industry.

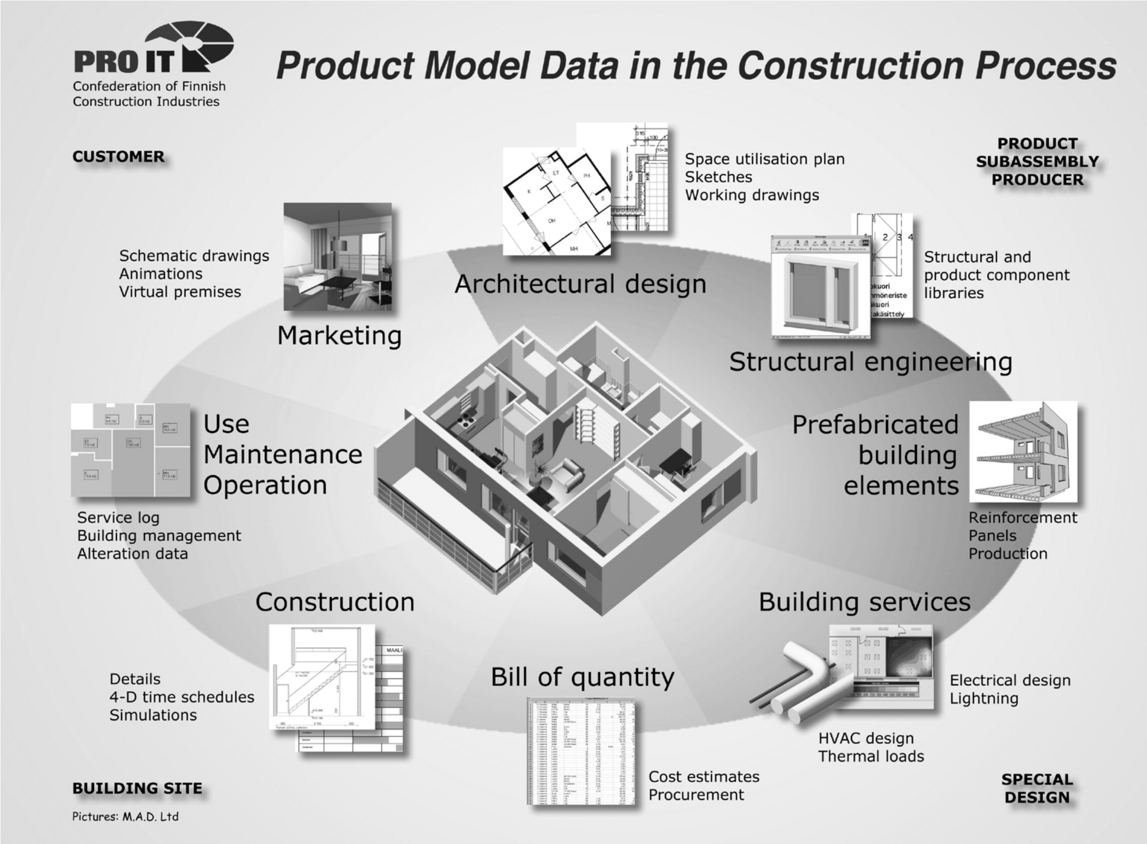

Figure 1. Product model-based data management for a construction project integrates the data needed for design, product manufacturing, construction, and the use and maintenance of the building.

2. The Advantages of the Product Model Based Process

2.1 Product Model Based Data Management

With the help of a product model, it is easier to keep under control all the data needed for the design, construction, usage and maintenance of buildings. The data can be managed in real time and in an intelligent and graphical form. The huge quantity of information needed in the successful realisation of a construction project can be transmitted between participants as well as managed more reliably and efficiently than before. An important possibility is to employ the structure and data content of the standardised product model to streamline and speed up the planning and control of construction projects. One of the most tangible direct advantages of standardised product models is that bills of quantities can be generated directly from the model for use in cost estimating, production planning and procurement.

The product data used in product modelling opens up a number of possible applications for the product industry [3]. Using a product description selected from a product library as part of a plan ensures a good technical and economical result, transfers the product data to manufacturing in good time, and also serves as a marketing tool.

Product modelling transforms building design from traditional line-drawings to visual 3-D design. In addition, a product model has in-built information available about the spaces, structures and furnishings it consists of. The structures of a product model such as walls and slabs contain information for instance on the materials they are made of, the measurements needed, and their thermal insulation, strength and environmental qualities.

When a 3-D product model and a time schedule are combined, the result is 4-D design. It enables site management to determine the most advantageous order of construction and the most economical time schedule from within an array of possible options. 4-D design also visualises the flow of worksite production and particularly problematic stages which demand more attention than usual from the site management.

After the planning and implementation phase of a construction project, it is possible to use product modelling to create a data store covering the entire life cycle of a building. The final product model shows all the materials and products used for the building, and can be updated when needed.

2.2 Product Model Based Operating Process

When one changes over from 2-D drawing to 3-D modelling, the production and management of designs are made more efficient: there is less routine work and fewer design flaws. Input data, such as quantities, are obtained automatically for various purposes and in the form of time-saving lists. The design geometry and dimensional accuracy come in handy in the design and manufacture of components.

Expertise from various fields of design and construction specialists is, through product modelling, usable in a practical form from the start to the end of a construction project. The inclusion of construction specialists in the design process improves cost-awareness and the possibility to figure in technical aspects of installation and manufacturing as well as allows room for innovative solutions. Instead of viewing the economy of a building in separate parts, it can be planned and assessed as a whole.

The last but not least of the ways in which product modelling improves construction processes is that it helps to achieve the goals the construction industry sets for customer satisfaction. It is crucial that the clients and end users of buildings are aware of the characteristics of the buildings built for them, that the buildings as end results correspond to their needs, and that unpleasant surprises are kept to a minimum. With the help of product modelling, the clients and end users of the building are provided with more information and specialist assistance to support their decision-making. The techniques used for this are visualisation and simulation.

2.3 Description of the Product Model Based Construction Process

The product model-based process supports exchanging and sharing data throughout the life cycle of a building. The ultimate aim is a process in which the product model data is produced, exchanged and utilised in an easy-to-use digital format between different software packages and participants. In order to arrive at this aim, it has been deemed most necessary that the participants of construction projects and the flows of information between them are systematically listed and described with respect to the different stages of projects.

The product model-based process has therefore been described by a systematic method (so-called IDEF0), in which the process is divided into sections. These are pictured as compatible diagrams which constitute a hierarchy. The diagrams represent the functions of each section, the programs used, the participating partners, and the data flows between them and their design software. The process model covers the life cycle of the construction project and the building from the preliminary design to the operating and maintenance.

3. Design Guidelines

3.1 Basics and Objectives

Uniform modelling guidelines for various designers of the construction process are necessary in order to transfer product models from one program to another. Being able to transfer product models between programs is a prerequisite for clash detection analyses of the models created by different designers and for ensuring that the bills of quantities extracted from the models are accurate. Furthermore, the data on the characteristics of product structures stored in a product model should be defined by a commonly shared method.

The modelling guidelines for the architect are the most crucial and demanding, as the model made by the architect serves as the input data for quantity surveying, for structural and building services design, and for marketing. It must therefore contain information for many different purposes – for example, spaces, building components and the principles of their connections. It is particularly important to transfer measurements to other plans correctly.

A key aim of the modelling guidelines for structural design is to provide basic data and instructions for the product-model-based description of structures and to influence that computer programs and the libraries on structural parts, details and joints are drawn up in line with the same principles of product modelling. General modelling guidelines also serves as an aid for drawing up project-specific modelling instructions. The guidelines can also be used to harmonise and standardise terminology, operating procedures and working methods.

So far, the third version of the guidelines of architectural design has been published in Finnish under the name Product Model Design Guidelines for Architects – General Rules and Fundamentals [4]. The first version of the guidelines for structural modelling has been completed, and at the moment it is being tested on real construction projects. The guidelines for modelling building services have also been started: currently, the content of the guidelines is being defined.

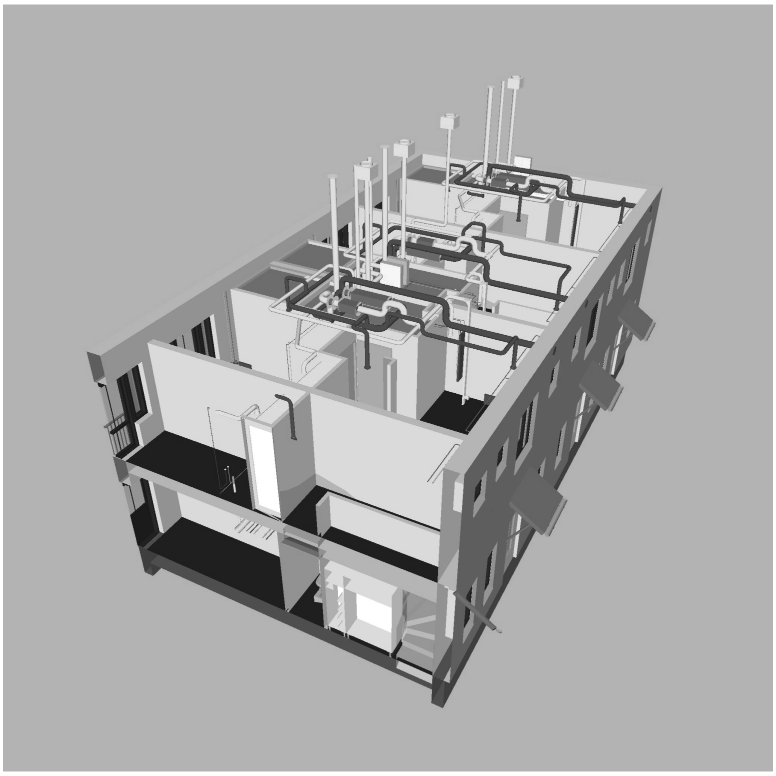

Figure 2. Combining the architect's model and the building services model and clash detection analysis reduces errors on the worksite.

3.2 Stages of Product Modelling

The designing of product models is divided into stages in accordance with the construction process as a whole. Descriptive terms have been agreed on for the different stages. These differ from the conventional terms, because product model-based design does not comply with traditional practice. The design model includes four stages: the requirement model, the space model, the preliminary building element model and the final building element model. The requirement model may be for instance a description of the client's needs and the building authorities' requirements, as well as the parameters set by conditions. This model may be represented in a spreadsheet application or other digital format.

The space model, in its turn, covers spatial solutions. The model does not yet necessarily include walls distinguishing the spaces from one another. The basis for formulating this model is the space utilisation plan together with its data on the individual spaces.

The preliminary building element model includes the elements which delimit the spaces and correspond to drafts in present-day design practice. Requirements are set for the elements, such as the fire class and thermal conductivity, but the structural solution is not yet selected. The building elements are defined at a construction type level. Ready-made construction types from the general product libraries can be used to create this model.

In the final building element model, the construction types shown are building elements together with product data, like the actual products of suppliers. In this model, supplier-specific data have been added to all the elements, accessories and so forth. The final element model may also include other information, such as time schedules and job plans. The models following the four actual stages of the design model are the as-built model together with site and installation data and the maintenance model in a life-cycle program. The maintenance model can later be updated with spatial alterations and additional construction.

4. Data Exchange and the IFC Standard

4.1 Data Exchange Use Cases

One of the key aspects in the product model-based building process is the interoperability of computer programs, and the support for the life cycle of the building information throughout the construction and operation process. A prerequisite for the realisation of this is to enable the digital data exchange of building information between the participants of the process and their programs. Then information once created by a participant and his or her program can be exchanged and shared with the downstream programs of other participants.

To enable the support for the many required data exchanges within the multidisciplinary building process, these exchanges need to be first defined, and then implemented as data exchange interfaces in the programs. The definition of the exchanges can be done by so-called *data exchange use cases*. A data exchange use case is 1) an identification of a business need for the data exchange, 2) definition of the information to be exchanged, and 3) definition of its implementation, for example, using a data exchange standard.

In the pursuit of advancing the practical product model data exchange, the Pro IT project has defined a set of necessary data exchange use cases. The use cases defined include the following exchanges:

- from architectural design to quantity take-off and cost estimation
- from architectural design to HVAC design
- from architectural design to structural design
- from various designers to design coordination and clash detection
- general quantity information exchange, e.g. from quantity take-off to tendering
- from product libraries to various programs.

4.2 The IFC Standard and How It Works

A data exchange specification called IFC (Industry Foundation Classes, [2]) has an important role within the data exchange use cases defined by the Pro IT project. The use cases define how IFC is used to implement the support for the exchanges.

The IFC is an open specification for AEC/FM interoperability. The scope of IFC is AEC/FM over the life cycle of buildings. IFC is developed by IAI (International Alliance for Interoperability, [5]). IAI's mission is to develop, promote and support the implementation of Industry Foundation Classes.

IFC specifies a neutral format in which programs can exchange digital building information. Using IFC, an architect can for instance send a digital building model created with a model-based CAD programs to an HVAC designer. The HVAC-designer could then use the model, its spaces, building elements, and 3-D geometry directly as input data for the thermal simulation program to calculate thermal loads and requirements. The same building model could also be used by a cost estimation program to automatically extract a bill of quantities and to calculate an initial cost estimate for the building.

All the Pro IT use case definitions follow same content structure: In the first part of it the purpose and scope, typical participants, and their program types are identified. Then the data content or the information requirements of the exchange are defined. The second part of the use case defines the subset of IFC object model which is required to support the use case. Examples and usage rules of the IFC are also given. The use cases are defined using a methodology including re-usable definitions, such that new data exchange use cases can easily be addressed and defined.

The data exchange use cases serve the purpose of a proposed common agreement on how IFC can be used to address real-life exchange requirements. The target audiences for the use cases are on one hand the participants of the construction process, and on the other hand the software developers, who may be implementing exchange interfaces for their design and construction programs.

5. Product Libraries

The Finnish construction industry has sought to standardise the data content and presentation of product structures so that the various participants in the construction process can use them. Both the definition of data with building component cards and product libraries for use in 3-D design are needed, so that designers are able to plan and manage customer demands, builders are able to estimate quantities and costs, and operators are able to use completed buildings and perform maintenance tasks.

One of the completed tasks is creating a structure library common to the construction cluster containing the most frequently used types of structure. The library currently includes over 200 different structures, which are mainly structures used in housing construction. However, the principles used there could be applied in the future to describe other, even totally new structures. With the common product model library as their starting point, companies will be able to create their own product libraries compatible with commonly agreed specifications.

The next challenge in the development of product libraries is to establish a link between common product libraries and specific products included in the product portfolios of manufacturers. The link would make it possible to choose specific products suitable for the design based on the general characteristics defined in common product libraries. The search for the specific products needed could be carried out for example by Internet search devices.

6. Pilot Testing

The piloting of the use and exchange of product-model-based data is an important prerequisite for the broader utilisation of product modelling. The construction companies involved in the Pro IT development project for product modelling are responsible for this. In the course of 2004, two contractors implemented and further developed the model-based process in their own housing output [6]. The software packages used in Skanska Oy's pilot project were ArchiCAD (architectural design), Tekla Structures (structural design), MagiCAD (building services design), Solibri Model Checker (checking models), ScaleCAD (element design) and NavisWorks (integrating different models and clash detection analyses). On NCC Construction Ltd's pilot, Bentley MicroStation Triforma (architectural and structural design) and MagiCAD (building services design) were used. The subjects of the testing were the use of modelling guidelines and product libraries, the transmittance of product models between programs, and the utilisation of product libraries in the design process.

In a pilot project of a shopping centre extension by Lemcon Oy, Tekla Structures software was used to model the structures. After the modelling of the steel frame, precast concrete units and the façade's thermo spar elements, these submodels were combined into a single structural model for the worksite. The main emphasis in the piloting work was on time schedule planning for the frame work stage and on monitoring installation data. By specifying the order of installation of the building components of the 3-D model and by inputting the scheduled installation dates of the building components into the product model, a 4-D model was obtained, containing the time schedule data for the construction project. The product model was placed on the Internet, enabling all the partners in the project to view a real-time 3-D image of the situation for installation on the worksite using nothing more than an Internet browser.

Advantages of product modelling among others that were repeated in different pilot projects were that it facilitated change management as well as the production of bills of quantity and various images and views. In principle, it is possible to generate all the conventional design documentation, such as drawings, from the product models drawn up. Product models have also permitted quantity listings of all the modelled construction components. As an example of the main benefits, it was noted that the time taken to calculate bills of quantities was reduced by an estimated 30-50% when using the new method. It must be admitted, however, that it is a prerequisite for such significant time savings in calculations that the subject building has been modelled comprehensively and extensively enough. The quantity data taken from the model have been estimated to be as much as 80–90% usable in making a time schedule for the construction project. In the project for an extension to a shopping centre, a graphic 4-D model proved itself to be an efficient tool for time schedule planning.

Other advantages include, for example, the possibilities to use three-dimensionality to assist design work and in integrating the work of different fields of design. A further prime advantage of product modelling that has emerged was the reduction in errors. For example, it was possible to eliminate measurement errors from designs almost entirely. It was also possible to use the product model on the worksite in many ways in the management of installation, logistics and complex delivery chains.

Most needs for further development were identified in data exchange between different software packages. Because IFC standard data exchange did not yet run satisfactorily, it was necessary to exchange data also using other, program-specific formats. The piloting will continue in 2005 on projects by four different contractors, in which the operating model and data exchange will be developed on the basis of the feedback received.

7. Conclusions and Directions for Further Development

The experience gained of the use of product modelling in the construction industry indicates that there is considerable scope for increasing efficiency in various subdivisions of the design and construction process made possible by this new method. The increased efficiency requires that common product modelling operating methods and data content definitions are finalised and taken into more widespread use.

The feedback so far indicates that compliance with architectural modelling guidelines and the use of general product libraries facilitates fast and efficient calculations of quantities. On the basis of the quantities, one may separately derive the costs and time schedule data. Quantity calculation and time scheduling are the first widely usable application methods where product modelling has proven its benefits. These methods are increasingly being used by construction companies.

Structural modelling is developing dynamically, and models can already be used not only for design but also for worksite 4-D time scheduling and production management. The structural model yields considerable benefits for the worksite using visualised plans and material listings. A structural model can also be used in the further design of building components, as has been done on the pilot sites of the Pro IT project. Building services modelling provides a visualised image of systems for purposes of installation, and it permits clash detection analysis and the design of the necessary provisions. The building services model can be used, for example, for simulating indoor air conditions and for dimensioning the energy consumption.

The main requirements for the onward development of product modelling relate to data exchange and the improvement of overall levels of expertise. For the development of data exchange, systematic work for the adaptation of the IFC standard must be continued so that it can be used to transfer the data required for different plans and for production between program solutions. Current data exchange is still based on file transfer. In the future, however, efficient team design will require the use of dynamic product model servers. From these servers, each designer will be able to access only the part required and to update the plan back onto the server. The first product model server solutions based on the IFC standard have already been created.

As a whole, the product model-based process is expected to yield substantial benefits to all the parties in the process. However, widespread adoption will still require considerable efforts. Particular attention should be devoted to developing standards for data exchange between design software, determining product attributes and creating product libraries.

Data exchange between different software should be developed by making it possible to widely apply the IFC standard. In practice, this will mean developing and expanding the IFC standard in such a way that it covers all the usage of data exchange required by the industry better than at present. Also, greater efforts on the implementation of the standard will be required of the software industry so that software will support the standard. Therefore, the standard needs to be developed a strong and international one.

The use of product data in the design, construction, use, and maintenance stages of a building requires information on the materials and solutions used as well as efficient and reliable electronic archiving. For it to be possible to create electronic product descriptions on the basis of the product data, the attributes of the product data should be defined internationally. On the basis of common attribute definitions, it will be possible to build jointly used product libraries and product symbols for software and to establish connections from them to different types of product libraries. This kind of product libraries will facilitate efficient marketing and comparisons between different products as well as promoting procurement on a broad level.

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Product Model Based Infrastructure Design

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Abstract

- There is a great need to develop the following sectors of the infrastructure branch:
- The quality of the design process
- The cost management during the design process
- Information management and communication between the different members of the design team

The result and the major cost level of the infrastructure project are defined in the beginning of the project planning and during the design process. Then the scope of the project is defined and the project is designed. Traditionally there have been problems related to the scope and information management. Now three companies have developed together with the Helsinki University of Technology the new product model based infrastructure design process. The process uses the best practise process of the cost engineering and the common product model.

Rakennuttajapalaute Rapal Ltd has developed with 10 major Finnish infrastructure clients (Cities of Helsinki, Espoo, Vantaa, Turku, Tampere, Oulu, Kuopio and Jyväskylä and the Finnish Road and Rail Administrations) the best practise process for scope management costing and cost engineering during the design process. Viasys Ltd is a member of the worldwide Vianova Systems Network and has developed the design software called Novapoint based on the product model. DSS Ltd has developed a program called DYNARoad for optimizing the earthmoving operations. Three companies have developed together a design process based on the product model, which is compatible with the InfraRYL (the new common finnish civil engineering terminology system). The product model based design process contains:

- The project scope setting method for infrastructure client before the design process
    - Systematic project scope definition method for the use of design management

    - The cost estimation based on the scope definition
- The design of the highway based on the previous definitions
- The optimizing of the mass operations in the project
- Cost engineering during the planning process
- The final cost estimate based on the infrastructure building element method
- Quantities of the final result of the design are given to the contractor for further studies

The developed design process with the common product model saves the great amount of resources during the long design process. The result of the design process matches the defined scope better than in traditionally used processes. The cost engineering and the product model can save millions of Euros in the big highway projects.

Keywords: Virtual enterprise, information exchange, information systems, distributed engineering, product model, cost management, earth moving operations, infrastructure management

1. The New Infrastructure Design Process

1.1 Overview

Three commercial companies (Viasys Ltd, Rapal Ltd, DSS Ltd) has collaborated with the Laboratory of Construction Economics and Management of Helsinki University of Technology to create new kind of product model and systematic cost management based infrastructure design process. Traditionally in the infrastructure branch there are many different kinds of data models in use and that makes lots of information waste during the process. The cost management process is not scope oriented and cost engineering in the means of getting economical and quality oriented design solutions compared to the scope is not in the common use. The new infrastructure design process is described in this paper concentrating on the cost management and data transportation.

1.2 Process Relevance

The difference between the reasons of the infrastructure project cost is related to three categories:

- The scope
- The design solutions
- The economical situation on the market

This article concentrates on all three categories in the view of cost management and the data transportation. The main benefits of the new design process are:

- The result of the design process corresponds to the defined scope better

- Data is not wasted during the long process
- The focus of the planning process is getting to the earlier stage of the process than before
- The focus is on the result of the process, not in the process

The infrastructure (highways, streets, railways and big industry yards) investment and maintenance cost in Finland for example were worth of 1,8 billion euros in year 2002. The relevance to the whole society is huge when lots of working hours are saved because of the more complete design process.

2. The Cost Management Process

2.1 The Systematic Scope Definition

The infrastructure is build because of the need to develop or to maintain the basic functions of society. The maintenance of the infrastructure is based on the need to sustain the standard of service of the invested infrastructure network. The change in the functions or the standard of service creates the need to invest more. The needs of the public and the resources in use with the property owner organizations are usually not at the same level. The building process of infrastructure is a long term process including lots of public organizations and ordinary people related to it.

The infrastructure cost management process described in this paper starts with the definition of the needs of the project. The client of the process (usually the public organization) has the responsibility to describe the need, give reasons to the need and take care of the cost management process to reach the target. The needs are modified to targets which are described with end product elements, which are big work breakdown structure components of the project like for example the main way, intersections, bridges and the lightning system (fig 1).

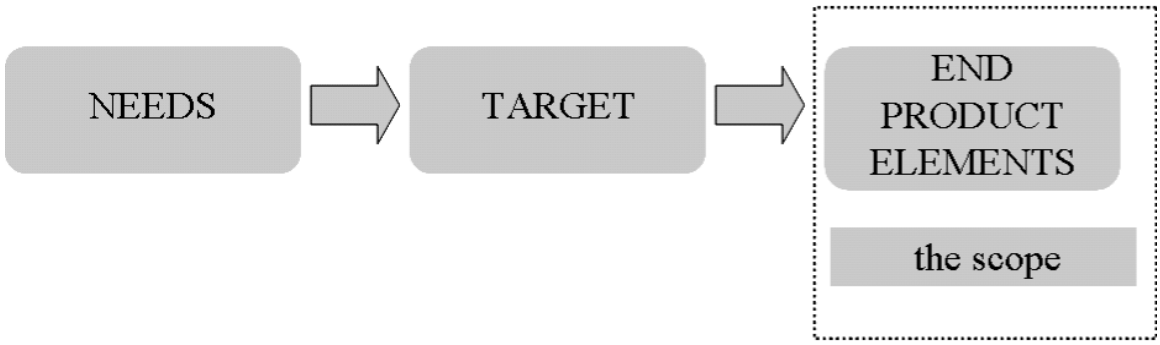

Figure 1: The needs of the project are modified to the targets, which are described as end product elements with the defined scope..

The list of the end product elements creates the framework to the project management based on the systematic and strictly defined project components. The systematic project component division with the end product elements has two purposes:

- To describe the result of the project
- To create the drivers of the project management

Traditionally in the infrastructure branch the process is design and project orientated. In this systematic scope definition the focus of the design process is moving to the earlier stage. There are three benefits of the earlier target orientated scope management:

- The design organisation has clear definition for the scope
- More cost orientated decisions can be made
- The design process can concentrate to the design process and innovations instead of definition of the whole project

2.2 Cost Engineering During the Design Process

The cost management of the project can be based on the estimate theory or on the steering theory. The difference in the two theories becomes concrete in the decision making points (fig2). According to the steering theory the decisions are made so that the cost is under the cost level accepted with the scope.

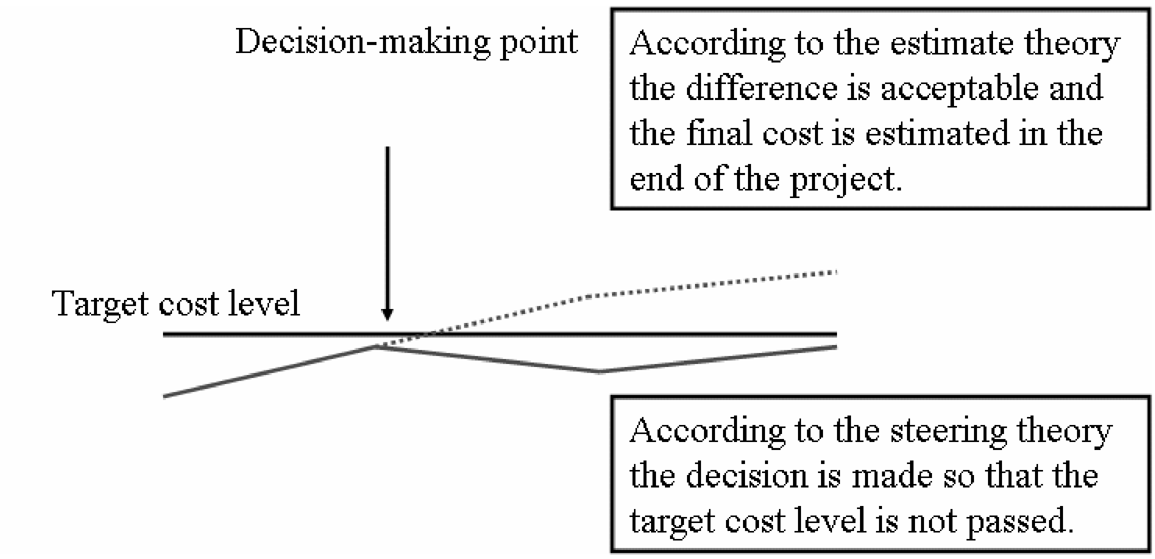

Figure 2: The difference between the estimate and steering theories

Traditionally the cost management is the final action of the design process and the result is more or less declaratory. The cost engineering during the new process is a continuous decision making process. It has three purposes:

- To get comparable prices for different design solutions
- To compare the design solution with the scope
- To estimate the market price for the execution of the project

The cost management during the design process is made with the building element system. The building element is a piece of the product defined in InfraRYL - the new common finnish civil engineering terminology system. The building element consists of the typical production structure in use and the price consists of the prices of resources (work, material, machines). The resource list is updated continuously by the data received from the markets.

2.3 Earth Moving Operation as The Important Part of the Infrastructure Cost and Schedule Management

Mass economy consists of the cost of earthmoving operations and the effect that used design alternatives and the available schedule have on them. These costs are always project specific and that is why it has been difficult and time consuming to estimate them in the past. If this has been done, the results have always has a high degree of uncertainty in them. DSS Ltd has developed a tool called DynaRoad to simplify parts of the process and remove some of the uncertainties related to it. The mass haul planning in DynaRoad is assisted by algorithms that do the all the haul and some of the schedule calculations for the user.

Mass economy calculation yields two major benefits to the design process: the cost of earthmoving operations and the weak spots in the designs that are likely to cause unnecessary costs during construction. The costs and weak spots are discovered by creating a resource based schedule and mass haul plan. This plan can be done in early stages of the project by using information on haul and resources costs that are readily available in the industry. A finished schedule and mass haul plan show an estimate of the project’s haul amounts, distances and resource and time requirements that are then combined with other cost calculation information. Analysing the mass haul plans gives the weak spots in the plan. These are for example:

- Structures that have a mass deficit or surplus.
- Structures that have long and large hauls related to them.
- Structures that may cause unnecessary delay to other tasks.

This information can then be taken back to the designers that can check if it possible to alter the plans in some way to get rid of these problems. For example, a mass deficit or surplus could be avoided by changing the vertical alignment of designs or changing the structure type to something that is (or can be made) readily available near by. Structures that cause unnecessary delay to other tasks could for example be embankments that rely on a cut that can only be done later in the project. This causes a delay on the fill and also all the tasks succeeding the fill.

The use of product models in mass economy calculation speeds the process by eliminating many of the complicated stages that have been previously necessary to get the required data from a design platform to a mass economy calculation system. Instead of using a day to set up a complicated project in the system the required data can now be imported directly from the design platform. After the product model development is complete it will be possible to visualise all the mass economy related information directly in the design software. This will further ease and speed up the work of the designer.

2.4 Benefits of the Systematic Cost Management

The cost management based on the scope management, the active cost engineering and active earth moving operation design gives the systematic approach to the infrastructure cost management. The new process makes different costs comparative and easily managed. The focus of the cost management and the planning of the earth moving operations are moving earlier than traditionally in the process. The more cost oriented design process gives resources to important points of the process and is feasible especially in the tight economic situation when the real cut resources are lower than needed (fig 3).

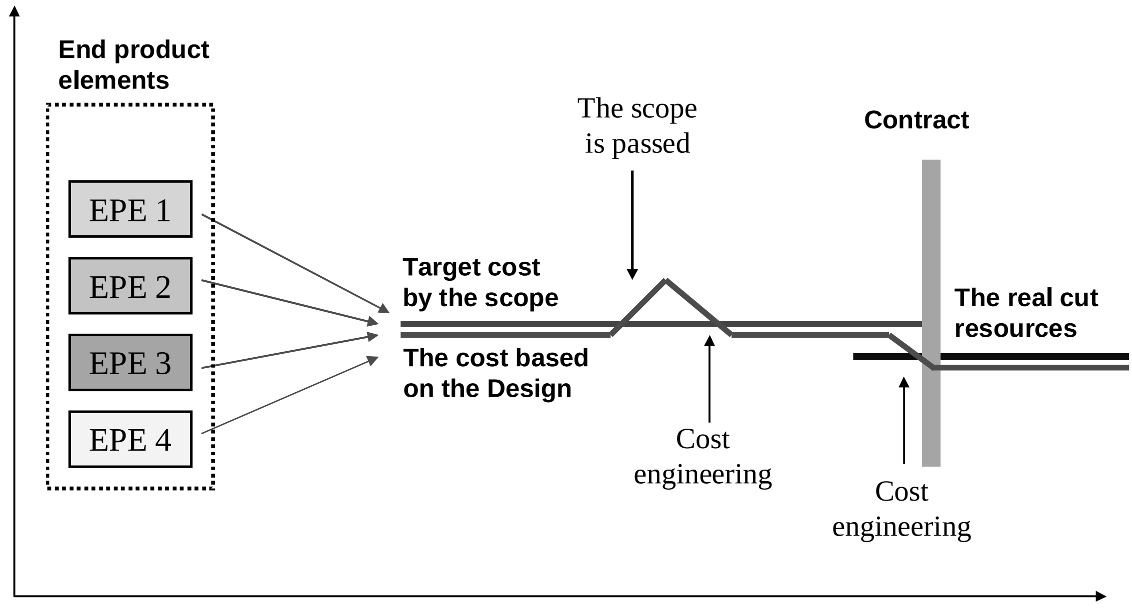

Figure 3: The systematic cost management process in the infrastructure design

3. The Information Process

3.1 The Common Product Model Description

Product model, in general, is an abstract class model describing real life objects and phenomena. Each class describes one type of real-life object. Class description consists in properties and methods. Classes are hierarchically associated with each other and properties and methods are inheritable based on association type. When any class in initialized, it becomes an object signifying a real-life object. During the object initialization, initial values of properties are supplied and initial methods are carried out. Thus, an object always contains some information. Furthermore, each object has a life-cycle and state of existence. With these basic construction blocks and rules, rather complicated real-life models and systems can be reproduced and utilized in computer memory.

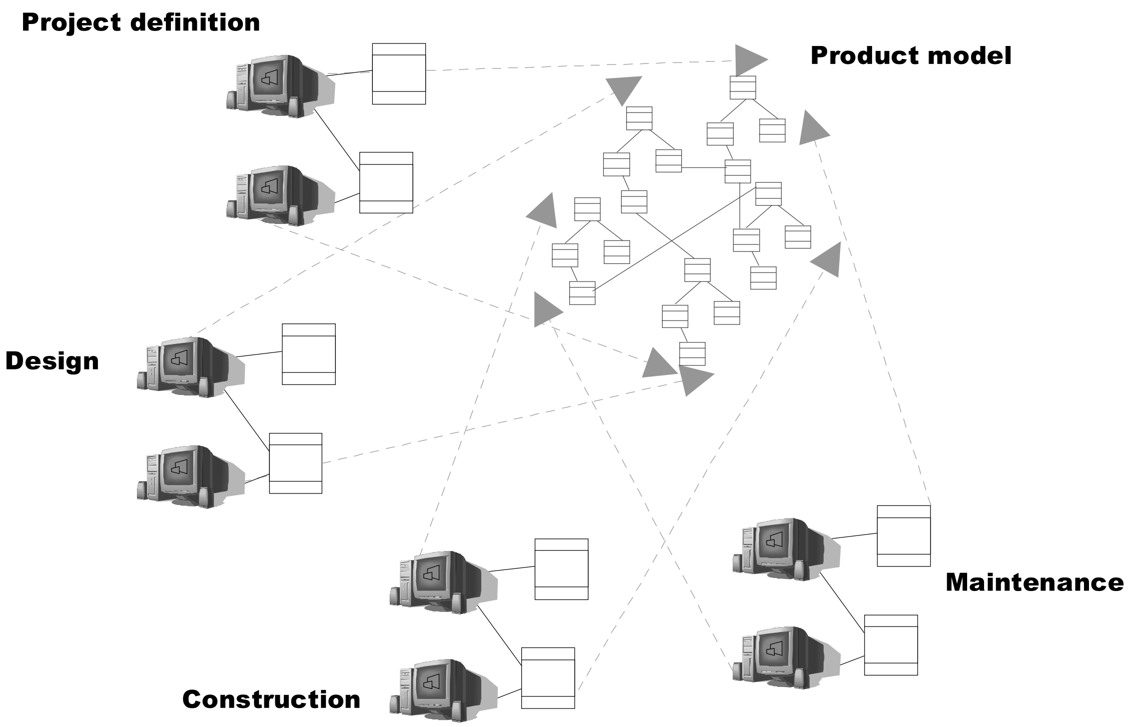

Figure 4: Different views to common product model.

Comprehensive and commonly accepted product model enables communication between different software with minimal or any data-loss. In ideal case the product model is well considered so, that the same product model is utilized in all software used in particular field of expertise. Figure 4, illustrates how the same product model is shared by different software in each phase of a public infrastructure management project. In each phase the product model is updated and developed further to meet the demands and outputs of the project phase at hand.

General methods and tools for holding a product model are, for example, databases, XML-files, text and binary files, in general, and data models in computer memory. Each application is able to read the common product model, or suitable parts of it, into application memory. Depending on the needs of the task at hand, the application view to the product model can be rather different from another application. For example, a cost management application does not need a detailed 3D-model view of a road, when a CAD-system is rather dependent on one.

Software used to produce and maintain the infrastructure design product model, in the concept described in this paper, is Novapoint product family (http://www.novapoint.com). These product model based design and management products are developed to meet the needs of Civil Engineering computing. The individual application modules, sharing the same product model, used in this concept are:

- Novapoint Road Professional
- Novapoint Terrain
- Novapoint Noise
- Novapoint Traffic Signs & Road Markings
- Novapoint Civil Construction & Novapoint SiteTools

3.2 Engineering with Product Model

The product model based infrastructure design process builds up gradually the road model in different project phases. Other relevant models included in infrastructure design process are some basic models, like ground and map models, and some domain models like road, water & sewer, traffic sign and road marking models. Thus, the comprehensive infrastructure design product model consists all of these models associated in strictly ruled ways. Each project phase uses the road model and other relevant models to achieve ones objectives and passes the evolved road model to the next project phase. This data flow in infrastructure design process is illustrated in Figure 5. Process phases are taken from a road design process and they are shortly described in paragraphs after this picture.

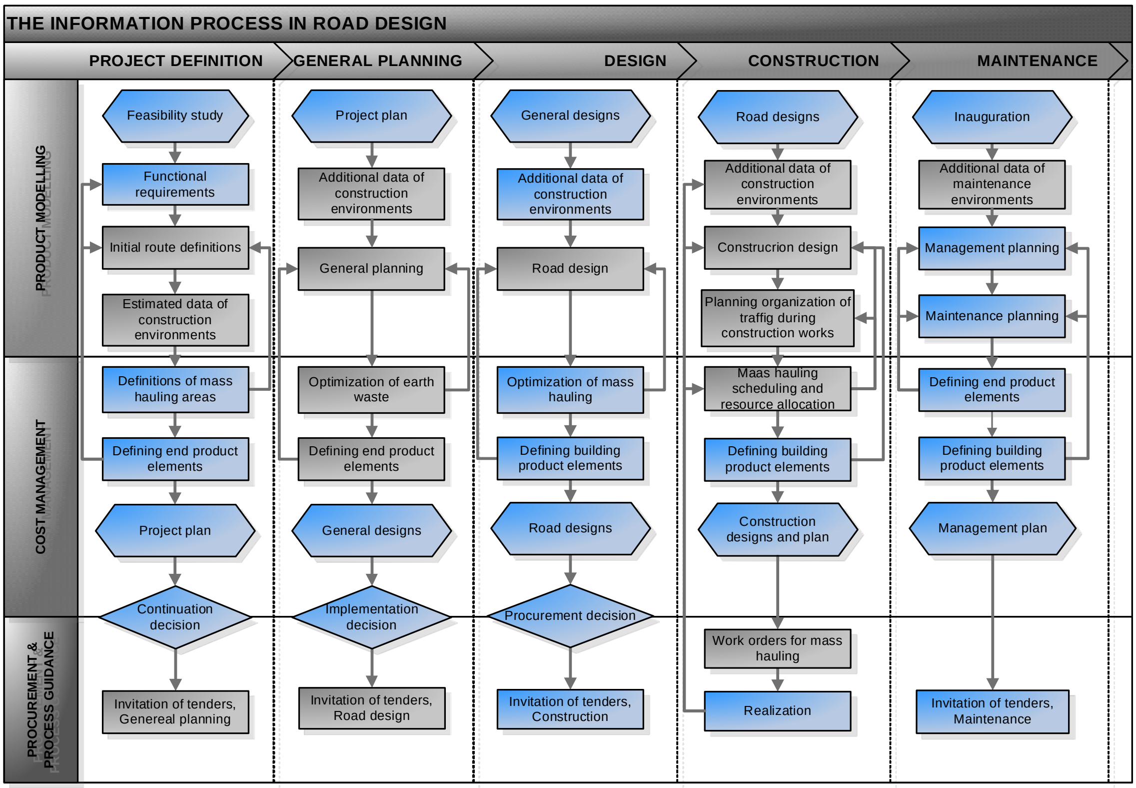

Figure 5: Road design, data flow in the information process.

In *project definition phase*, the product model is initialized against one or more very roughly defined routing alternatives. Systematic project scope definition process generates initial product models and sets of end product elements, with different functional requirements and routing, for comparison. Construction environments conditions and characteristics are roughly estimated in order to gain comprehension of construction difficulty level and costs. Also the first definition of mass hauling areas should be carried out. The risk of miss-approximating the costs, at this phase, are relative to the level of information about construction environment. The systematic project scope definition process outputs are one or more product models with "one-dimensional" parametric road model. The road model, in this phase, lacks any geographical manner of expression. The parameters of the road model set rules for design process in following phases.

In ideal design process the designer receives, after project definition phase, the initial product model in digital form. The designer is able to start more detailed design work immediately. The design work is guided by the product model parameters. The designer is able to deviate from rules set by parameters, but the designer is obligated to have good arguments for any deviation. *General planning* includes also environmental impact evaluation, like noise calculations. Combining all available information the designer is able to produce further developed product model. The road model gains initial alignment and horizontal profile. This enables first trend-setting mass calculations and optimization of mass usage. Basic information gets more specified and the set of end product elements can be decided. After the first ground setting designs, the costs of the construction are quite fixed with some deviation limits. Cost deviation is possible within the allowed change-limits of alignment and horizontal profile. Also the costs of actual building process elements can vary.

During *road and construction design* phases the product model is developed into very specific level. The product model is completed and the basic information of construction environment is detailed enough for construction planning purposes. Based on completed road model, the designer and the contractor are able to decide the comprehensive list of building process elements. The completed product model is delivered to mass optimization software for analyzing. The mass hauling optimization process is carried out and earth moving operations scheduled with allocated resources. The mass hauling optimization process is iterative in nature. If it becomes obvious, that in order to achieve mass balance, there has to be some design changes, the product model is returned to design software for revision. After this, the economical risks are again estimated based on the amount and accuracy of construction environment information.

The mass hauling schedule becomes the backbone of infrastructure construction project. Surprisingly, in modern road construction projects the mass haul planning can be quite demanding task. In major, road construction projects realize in road sections already in traffic-use. Construction works are not allowed to cause disproportionate blocks of traffic. Based on mass hauling plan, the planning of traffic organization during construction works is carried out. This action requires that the product model enables delivery of mass hauling plan to design software. In design software, the mass hauling plan is analyzed and required temporary structures, traffic signs and markings are designed.

During the construction works, the product model is utilized again. By the use of product model, the contractor is enabled to produce, within design software, daily or weekly work orders with guide maps for mass handling actions. The work order can also be used for reporting the realization of mass hauling works. These reports are inputs for realization analyzing. Based on realization analyzes, the contractor can produce estimates and revision of the construction schedule. Quality control of the infrastructure is carried out by as-built measurements during the construction works. As-built measurements are inputs for analyzing, among other things, realized masses, structure thicknesses and slopes, as well as keeping the agreed tolerances. While analyzing the as-built measurements against the product model, one builds up the product model of realized infrastructure.

3.3 Benefits of the Product Model and the New Design Process

The benefits of product model based design process are quite obvious when one thinks the process trough. One might ask, is there any other intelligent way to do this? All information produced during the process is somehow linked or based to previously produced data. So called rule based designing, managing data in similarly controlled way in all project phases and utilizing common product model in design process enables guidance of the design output and ensures that the functional requirements of the structure are fulfilled. This process approach also brings more economical predictability and fewer risks to infrastructure design and construction. Also, when the product model is sensitive against inaccurate or faulty basic data, the economical magnitude of possibly realizing risks is known and can be budgeted for.

4. The Benefits of the Process

The benefits of the new product model based design process are:

- The cost management is based on the real defined scope, which is a target for the cost management
- The scope and the design solutions are comparative through the design process
- The data transportation between the systems and the organisations is fluent because of the product model and data is not wasted
- The systematic cost management and data transportation save the amount of the working hours, which were used to routine work
- There is more time to research the alternatives and innovate

5. Conclusions

The infrastructure management is traditionally organised by public organisations. The cost management and the data transportation were developed by the organisations in the branch separately with no collaboration. Now the world has changed. In Finland the public sector is concentrating to the property owner duties. The actual construction and maintenance work is done by the private companies. The property owner has to concentrate to the role of owner in the world of tighter resources. The product model based design process is still developing. The companies are building up a new development project with the University. The results from the piloted process so far indicate that:

- The focus of the design process needs to be in the earlier stage of the process
- The design should be more cost oriented, now many cost effective decisions are passive parts of the process
- The new common nationwide or even more nations covering data model should be developed and taken in the use
    - now too many resources are wasted to routine work
    - now too much data is wasted

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The Virtual Cooperative Project: An Aid to Building Cooperative Design

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Abstract

The main objective of our research is to develop a tool that helps the management of a building project and aids cooperative design. In this paper, we present a cooperative system called Bat'Map developed according to the model of the Virtual Cooperative Project. This new model of cooperative design takes into account the relational organization of the project and the semantic meaning of works. This system lets geographically dispersed project actors model the project context of a building. More specifically, it allows interpreting, using and exchanging project works in a centralized virtual environment during the building life cycle. This system uses IFC objects which associate in the same model the semantic and the 3D representation of building works. This research represents a new approach because it not based on management of documents but on all data relative to works. So, in the first part of this article, we propose to view collective typology of building domain activities and the exchanging data mode of cooperation tools. The second part of this article illustrates the IFC model. Then we justify the interest shown in a model of cooperative design used for defining a design-aided tool, to deduce advantages and limits of the "Virtual Cooperative Project".

Keywords: Cooperation model, cooperative work design, project management, digital mock-up

1. Introduction

Architecture design is by nature an integrative discipline, drawing upon a wealth of knowledge. It has a strong tradition of interpreting its results not by scientific metric knowledge but through self-referential validation [1]. In fact, an act of design is a designer's interaction in a group of designers. Points of view are often shared between contributors, and decisions about different project aspects are submitted for common approbation. The global organization of the design process allows actors to develop and to prescribe tools and methods improving design. Most of these tools are unsuitable because they don't sufficiently take into account the cooperative dimension and the implicit nature of building designer work [2]. It does not enable them to treat all the semantics of the works especially the one relative to cooperative design (difficulties in tracking actor's work, lack of all the required information, coordination problems, etc). So, in this paper, our objective is to define a tool that must help designers to obtain maximum project context data and structure works semantic meaning, which allows good objectivity in decision evaluation. This will be able thanks allowing actors to get reliable data concerning the state of the project in order to determine what the actions to be carried out are.

This paper will briefly review collective typology of building domain activities as well as the data exchanging modes. It will then illustrate one vision of the digital project deduced from the analysis of the IFC object model "Industry Foundation Classes" imported for construction. The aim is to identify the capacity of the current IFC digital mock-up to structure the cooperative design activity. After that we justify the interest shown in a new model of cooperative design where the relational organization of the project and the semantic meaning of works are taken into account. Finally, we use this new model for defining a design-aided tool, to deduce advantages and limits of the “Virtual Cooperative Project”.

2. Cooperative Design in the Building Domain

Design activities correspond to a sharing of a space, which contains common and shared objects. This space is always extended by individual contribution (in cooperation) and by collective contribution (in collaboration). This co-production is structured by actors’ coordination.

2.1 Collective Typology of Building Domain Activities

We differentiate three categories of collective building domain activities:

- Cooperation is defined by acting jointly through a non-structured informal relationship. The rules are invented progressively. The coordination is founded on an implicit mode between the actors.

- Some authors like Dillenbourgh (1995) and Lonchamp (2003) [3,4] explain that collaboration is one elaborate form of cooperation. It consists of teamwork producing common work. It requires a large amount of explicit coordination with precise and hierarchized progress (Table1).

- Coordination allows the group members to articulate each action to design and to realize together collective products. Coordination is the mechanisms through which individuals integrate their productive activities [5]. It interferes either at the moment of the final assembly of the partial contributions in a cooperation setting, or throughout a task realization in a collaboration setting. The coordination organizes and structures the cooperation and the collaboration activities: it is inseparable from either of them. The coordination constitutes the mode by which the collective activity is sure to be efficient.

Table 1: The difference between cooperation and collaboration.

	Cooperation	Collaboration
Work mode	Acting jointly	Working in a team
Objective	Actors have a common objective but don't have a common underlying objective	Actors have a common objective and a common underlying objective
Evaluation method	Actors are evaluated in group	Every actor is evaluated independently
Relation nature	Relations are not definite and are unstructured	Relations are lasting
Activities progress	The rules are invented progressively	Activities' progress is known and hierarchized
Coordination type	Large amount of implicit coordination	Large amount of explicit coordination

The collaboration, cooperation and coordination operations are the basis of group activities. Collaboration is an activity where processes are known and repetitive. On the other hand, every building actor works to carryout underlying tasks, and cooperates to assemble their contributions in a common production using coordination. Design is an important building collective activity of reciprocal prescriptions. In a design project, actors cooperate to achieve a same objective, which can be the production of documents, solutions, comments, etc. Criticism and negotiation represent important decision actions. Because of the implicit character dominating in the building domain, a great number of heterogeneous variables are taken into account to design and to construct. As result of this, actors must cooperate successfully and have assistance to save time and money. Today, actors use more and more tools to assist their work, and technologies to structure their exchanging of data and to manage building project.

2.2 Data Exchanging Modes in the Building Domain

In construction, there are two types of cooperation approaches. The first one is founded on documents and exchange files. It is structured by several data exchange practices: manual management of exchanges (sending disks, maps, etc.), exchanges by electronic Email, exchanges through PDM, cPDM[1], etc. Some of these practices save time and are efficient through big projects, etc. Some others show little trace of sharing and are submitted to precise structuring rules for drawing up documents, etc. The second cooperation approach is based on the use and the manipulation of the semantic meaning of a project. It constitutes an experimental practice

[1] Product Data Management (PDM) is a component of the technologies of data products. This concept covers the set of techniques, methods and tools aiming to communicate, on an electronic support, the product data within a company. CPDM is a cooperative Internet version of the PDM.

which consists of sharing a digital mock-up[2] and modeling building projects with interoperable objects. This practice has not yet shown its efficiency, but is being followed with great interest.

3. IFC Digital Mock-up Model

A large variety of CAD software is proposed in the engineering domain. CAD software is specialized for civil engineering professions and has its own modeling concepts [6]. The data exchange between CAD software is so difficult, due to the heterogeneity of the modeling field. Most of these software solutions are based on proprietary solutions with their specific technical model [7], and model the building with 2D geometry. In this formalism, no semantic information specific to the building objects is modeled. To bridge this gap, the International Alliance of Interoperability has proposed a standard called IFC that specifies object representations for construction projects. Industry foundation classes[3] (IFC) include object specifications, or classes, and provide a useful structure for data-sharing among applications. A door IFC, for example, isn't just a simple collection of lines and geometric primitives recognized as a door; it also has a door's attributes (material specifications, prices, etc.). The adoption of this standard by all the leaders of CAD software allows a better interoperability in the exchanges of information between the various civil engineering professions.

The IFC product model is a universal model for the description of buildings over their complete lifecycle. It has been one of the strongest aims of research and development since the early days of Computer Aided Design in the building industry [8]. In the IFC, we found a "product model" that uses the STEP[4] norm. IAI had adopted many STEP industrial standards, but their building sector adjustment raises some data exchange problems:

- The trace of actor actions: IFC model show tangible blanks about intervention traces and the actor role definitions in the development process of a digital mock-up. Until today, we cannot indicate whether an object has been proposed or validated by an actor (IFC 2.X release) [9].

- The project evolution cycle in digital mock-up: During the design of the different objects making up the project, the IFC model doesn't permit us to assign them the progression levels defining the project evolution. We cannot know if an object is under design, under modification or already validated.

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[2] The digital mock-up is a graphic computer representation, in 3 dimensions, of project works and spaces evolving throughout a life cycle. This representation is partial and reflects a given point of view of an actor. (Ex: the digital mock-up of a climatic engineer, of a structure engineer, etc.)

[3] Industry Foundation Classes are currently the more successful to constitute the shared digital mock-up realization in the building domain. The IFC represent a standard of exchange and sharing of data [10].

[4] Standard for The Exchange of Product data model: are international computer exhaustive descriptions of physical and functional features of any industrial product type during its life cycle.

- Semantic meaning used to design works: In the latter IFC update, we cannot attach to every object its manufacture constraints, its rules for setting up, etc. (Among the set of model attributes, there is no specification about regulation rules, structural characteristics, plastic qualities, etc.)

Thus, IFC model shows lacks relative to the cooperative dimension. This model must takes in account the flexibility of current practices and operating mode of project building: so the structure interest of the all exchanged semantic meaning relative to project works.

4. A Cooperative System Developed According to the Model of the Virtual Cooperative Project

In a design cooperation process, the fact that building actors get reliable data concerning project states, helps them to determine what the actions to be carried out are. When concentrating on the data exchanged during the project design, the works are the main focal point. In the same way, every project work holds some relation with its ‘environment’: with the actors who designs it, the documents that represent it and the activities that create it. Our objective is to provide actors with a real vision of the design process evolution thanks to a digital project (Figure1).

The digital project constitutes the set of data defining works constituting a building. It is an expanded data representation of the different updates of digital mock-ups during the building’s life cycle. This project is created and shared by all building actors (according to right to access) on an Internet platform. Every actor’s action on documents and works is traced and linked back to the actor. In a digital project, exchanges are managed and facilitated thank to the use of interoperable standard data. The digital project constitutes a virtual cooperation environment for structuring cooperation and communication activities.

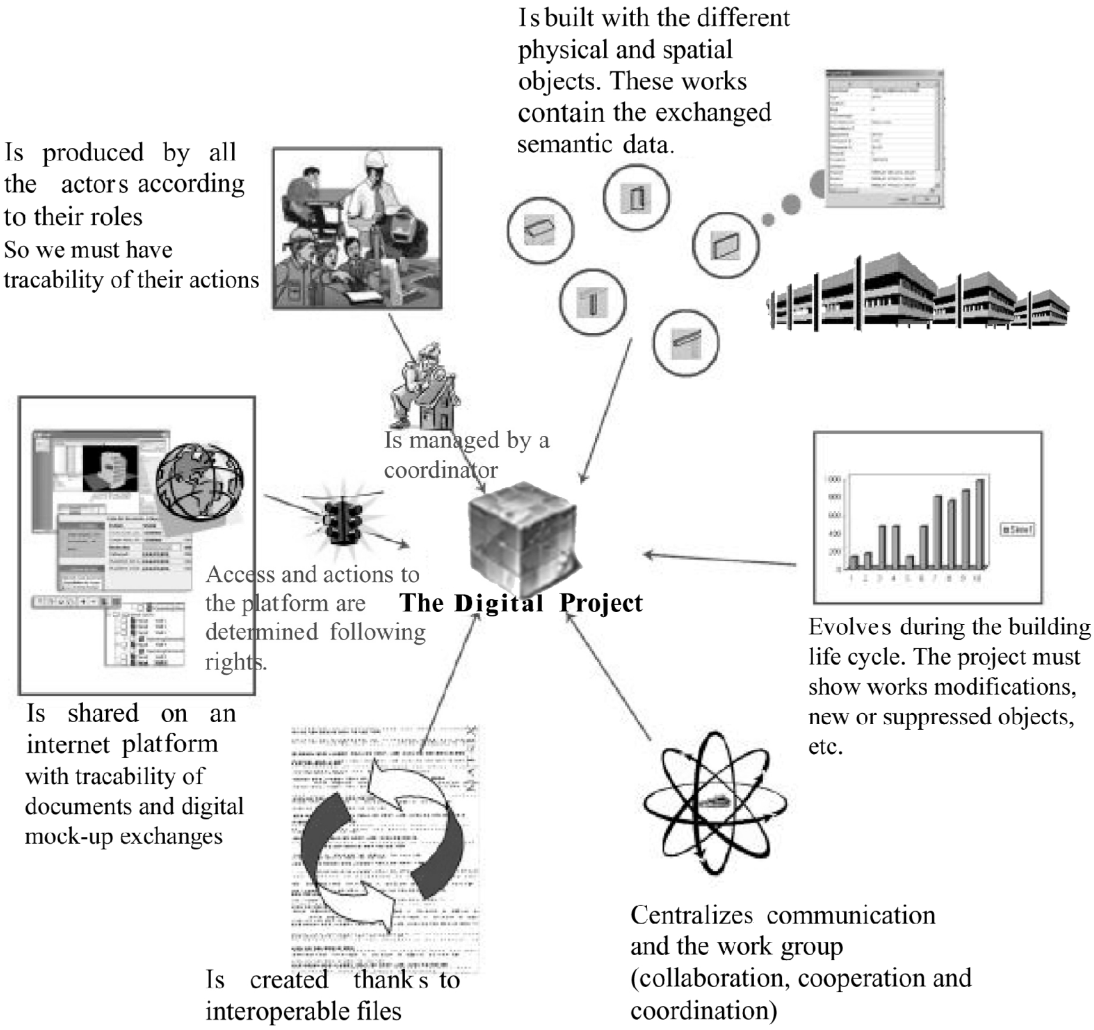

Figure 1: The different dimensions of a Digital Project

4.1 The Meta-model of Cooperation and the Work Model

We propose a cooperation meta-model[5] that allows the taking into account of the existing relations between the elements of a project (actors, activities, documents and objects). The instantiation of the objects allows the definition of the VCP. The Virtual Cooperative Project (VCP) is a project that we have initiated in the co-designing domain, having as a target the definition, the design and the realization of a model able to assist cooperative design in architecture using works (instantiation of objects).

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[5] This meta-model is described in MOF 'Meta Object Facility' [11], and used to distinguish concepts, which are common to every design project practice.

A work represents a physical object making up the basic brick of a digital mock-up. This object is characterized by its geometrical and topologic data but also by its semantic meanings. Every work belongs to a class, possesses attributes, relations and is set according relative constraints. A work is the result of coordination activities given during the project and throughout the design cycle until the realization. The works have different design phases and indicate the modifications that they have incurred as being associated with the actors who use and modify them. In the Virtual Cooperative Project, the model of work is structured on 'simple work' (indivisible building work) and 'composed work' (composed of simple works)

The work's semantic meaning represents all data excluding geometrical and topologic data, and is used to define work all along its life cycle. So, in the objective of structuring an aid to the works' design, trying to group maximum data throughout their creation, we have set up a classification table of semantic meaning used to design a work (physical attributes, regulation constraints, structural properties, financial aspect, etc.) However, we distinguish five subtype classes of the 'simple work' following a professional logic taking account of the notion of design evolution during building life cycle: we design structure works first, then those of partition, of equipment, of cladding and finally accessory works. Finally, works maintain four types of relations:

- The relationship between activities and works is distributed in time and shows the works' evolution during the building's life cycle. It is a dynamic relationship. For example: a project generates a digital mock-up; a digital mock-up evolves in a phase; tasks and requests concern works, etc.

- The relationship between actors and works is referential and associative. It indicates actor's interventions on works. It is a dynamic relationship and allows us to distinguish each actor's design work and reflect point of view. For example: an architect creates, modifies, deletes, or validates a work, etc. The study of the relationship between actors and works allows us to identify the relevant semantic meaning related to building works, for each actors' profession. So we have used the classification of works' semantic meaning and the several actors' professions, to set up a table identifying semantic types that interest mainly each actor[6]. This table enables us to develop in Bat'Map a personalized digital mock-up visualization for the different actors.

- The relationship between documents and works is relative to the data specifications. It is a static relationship. For example: a document describes a category of works, a work makes reference to some documents, etc.

- The relationship between works is relative to their design. We distinguish those linked to their development and those linked to their space organization, as a dynamic relationship. We distinguish too those linked to the nature of the relationship between physical parts, as a static relationship. For example: a wall is set on a floor, a beam holds a column, a window is situated in a wall, a digital mock-up evolves in another update, a wall is subdivided in to several walls, etc.

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[6] This table is established thanks a statistical survey applied to a several number of actors in four French building analyzed projects.

4.2 The implementation of Bat’Map

To manage a project ‘type VCP’, which generates a great quantity of information; we have used an interactive navigation interface to develop Bat’Map. This graphic interface constitutes a tool for the cooperative management of a digital project. Bat'Map aims at total structure of the project context using nodes and links. Different types of icons represent the fundamental concepts of a Virtual Cooperative Project (Figure2).

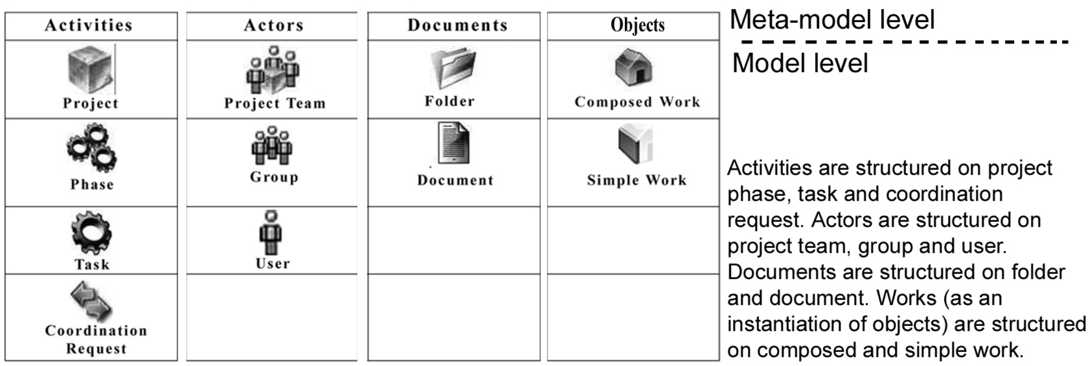

Figure 2: Icons representing concepts of cooperative activities in Bat’Map

On the other hand, Bat’Map is a computer-based system that supports actors engaged in a goal and provides an interface to a shared environment. Bat’Map allows users to initiate a cooperative project environment by identification of actors, activities and documents. When the first update of the digital mock-up is created (‘.ifc’ type file), a coordinator proceeds to its download from a Bat’Group[7] web platform (Figure 3). The system interprets (thanks to a parser[8]) IFC’s data relative to the works; visualizes digital mock-up using a “composed work” node and the works composing it using a “simple work” node. When deposing this first version of the digital mock-up (for example by the architect), the creator will have an automatic link with all works making this digital mock-up.

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[7] Bat’Group is a groupware developed in our laboratory CRAI-France. Bat’Group as Bat’Map gives to each actor an adapted vision of the project context, concepts of actors, activities and documents [12].

[8] We have developed a parser, which converts data relative to works contained in the IFC file (written in Express) to compatible data with Bat’Map interface (written in Java)

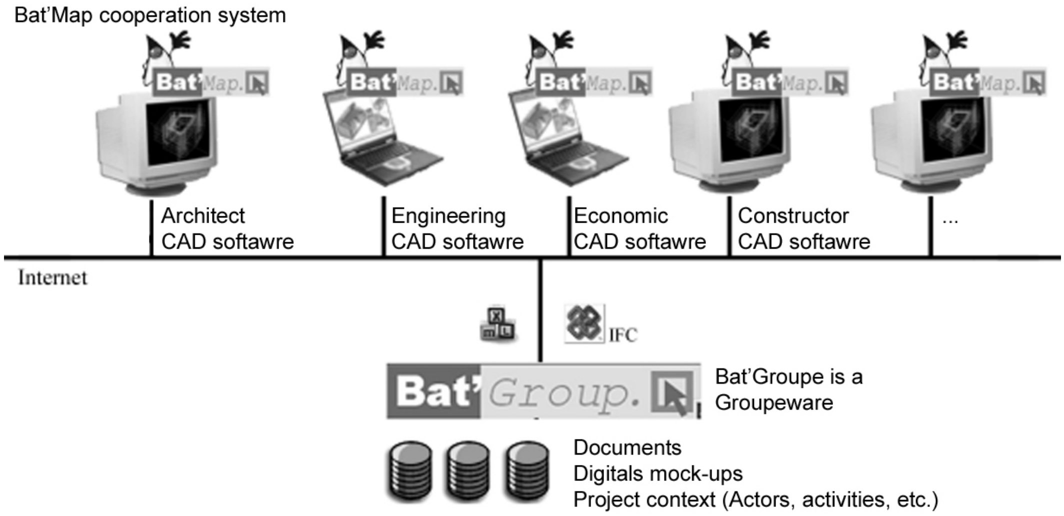

Figure 3: The Bat'Map context use.

When updating digital mock-up, the works evolve. So to identify the new modifications, we adopt 8 states relative to the works. Every work evolves and has different states. A node state represents one work evolution context and is represented by different icons. We have used colors to distinguish cooperation states: inactive object, active object, an object submitting a problem and an approved object. Then, we have used different icon forms to distinguish development states: a suppressed work, a new work, a modified work and a work without change.

Every digital mock-up update, the system proceeds automatically with identifying changes to works, thanks to a comparison between the ".ifc" data. Then, the system proceeds with linking works to the actor (author of the new update) as the one responsible for the suppressed, modified and new works. Works without change are linked to the last update designer, etc. These links between actors and works allow action tracability during the project design.

To facilitate navigation in Bat'Map, we have developed filters and functions allowing an adapted navigation following user needs (to show only works nodes, only actor's nodes, etc.) On the other hand, we have integrated an 'IFC 2.X Release' viewer to allow designers to visualize works. A 3D visualization lets participants move around and in the building. That allows designers to obtain information about the objects that comprised it. Likewise, users can specify in Bat'Map links to other software, in the objective of visualizing text documents, pictures, maps, etc. Finally, we have adapted and developed in Bat'Map works representation and semantic table visualization for each actor's profession.

We conduct two experiments to test the Bat'Map capacity to assist cooperation design in a building project. The script adopted for the experiments describes the design of two buildings (a wooden salt store[9] and a building extension in France). Actors coordinate themselves in a distributed asynchronous mode. The script steps cover: the building evolution throughout analyzed phases, the cooperation activities solving design problems, the digital mock-up updates, the validation of phases, etc (figure 4).

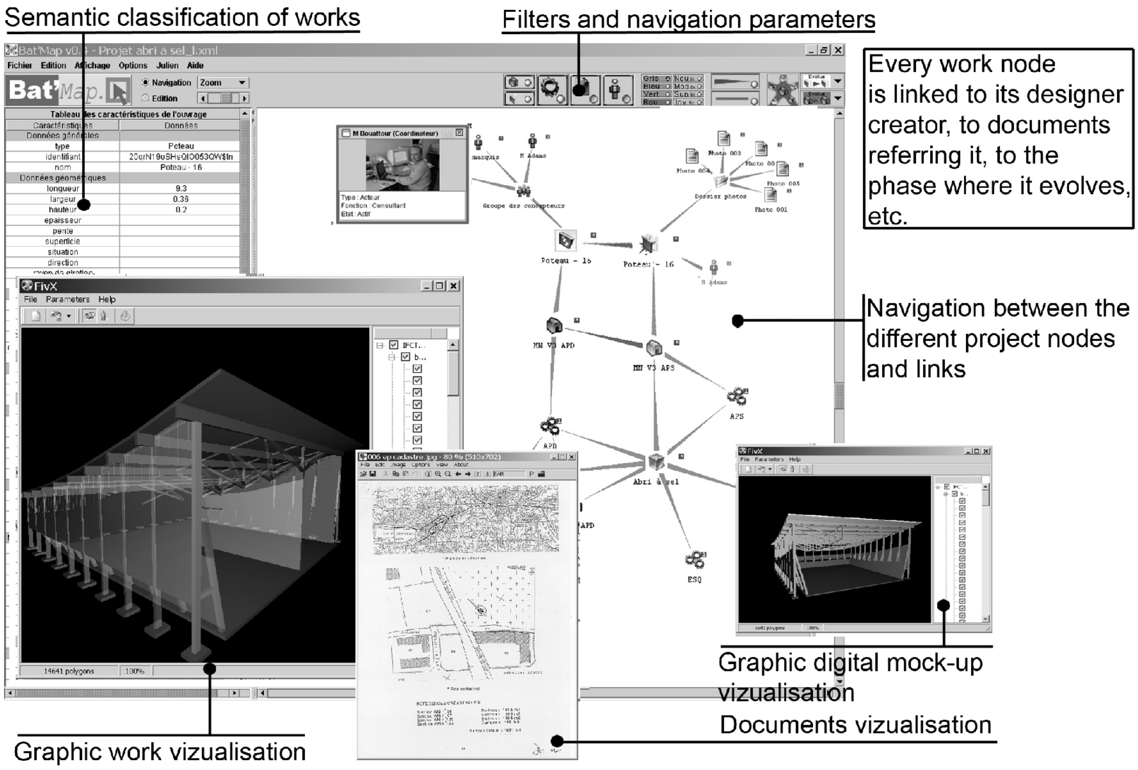

Figure 4: Visualization of the project context of the salt store with Bat'Map.

As a result of experimentations, we notice firstly that the representation of cooperation design context of a building permits a global view of the project: actors, phases, tasks, documents, works and relations between these concepts. Secondly, comparison of several digital mock-up updates during all the phases of the project allows designers to save time when they have to identify changes between updates. Bat'Map allows users to have a clearer view of the building life cycle, and to trace all actors' actions on works and documents. This constitutes a great assistance to the project management. Thirdly, semantic meaning management of works represents a design aid. The fact that designers use all the documents and data relative to a given work, allows for good objectivity in their choices, and enables them to take into account a maximum constraint. Finally, like filter functions, the visualization adapted to actors' professions allows users to have a clearer personalized vision of digital mock-ups and work semantic meaning (figure 5).

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[9] Salt store is a building used to protect salt against damp. It is employed for the bulk storage of salt. Salt is sprayed on roads against to protect frost.

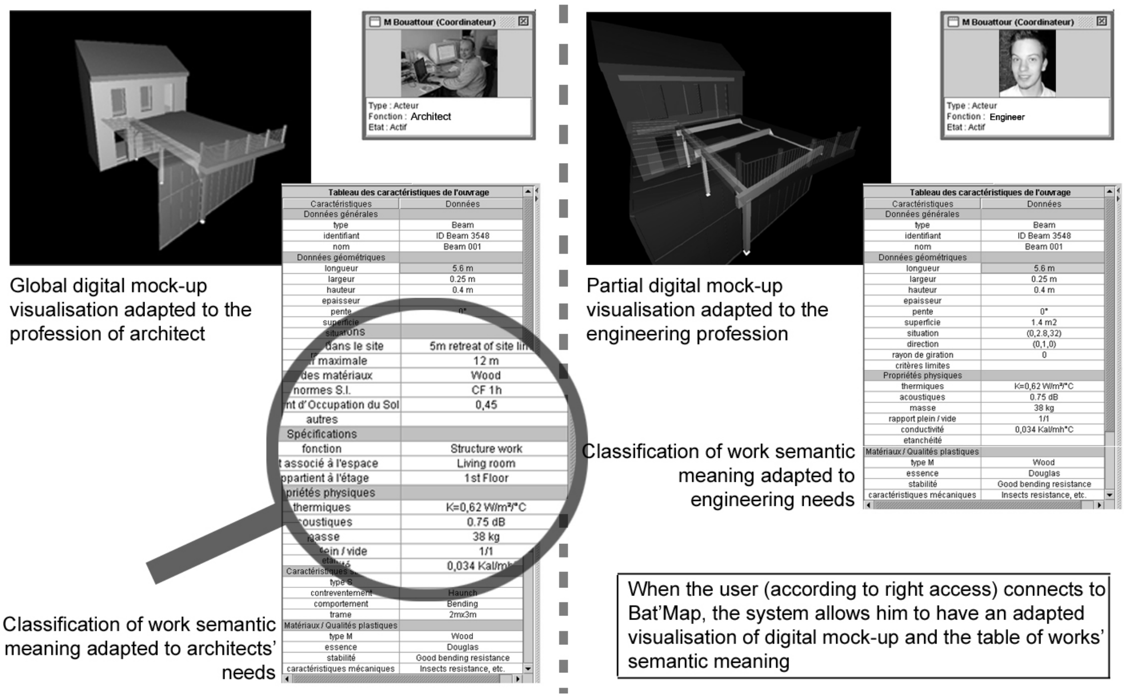

Figure 5: Adapted visualization in Bat'Map.

5. Conclusion

The European Building and Construction industry is to a great extent dominated by small and medium size enterprises. The fragmented nature of this industry necessitates cooperation assistance tools to enable users to design buildings efficiently and manage projects. This paper presents a new approach of cooperation aided-design, which proposes a new data organization of building context, by the representation of the existing relations at same time on the site, and also inside the project. The works are on the basis of Bat'Map (V4.0) development. This cooperation system provides a set of processes, functions and databases placing the IFC at the heart of the project context. The main advantage of using these objects is to provide actors with structured data related to the semantics and the 3D representation of building works.

Bat'Map is developed according to the model of the Virtual Cooperative Project in order to reinforce cooperation and group awareness. This system proposes the structuring of a cooperative project context. It proposes partial views which allow actors to navigate in a virtual environment, to be informed of the progress state of cooperation activity, to study latest digital mock-up updates and changes brought about, etc. The identification of the different states of works allows actors to have a clearer idea of every work and digital mock-up statute. The semantic meaning thus obtained permits actors to adapt their vision of the design evolution and to avoid wrong decisions. The results of the study also show that the visualization of the different digital mock-up updates allows us to have a trace of actors' actions (author, date and modification objects), saves time in the identification of changes and allows us to specify the respective responsibilities linked to modification, creation or forgotten works.

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Attaching Requirements Management to IFC Product Model

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Abstract

In this paper, preliminary results from the ongoing Finclad2 project are described. Finclad2 is an enterprise driven synthesis of two bridging projects coordinated by the Finnish Constructional Steelwork Association (FCSA). The focus in these projects is on the development of design and decision support tools and on combining requirements management with product model environments. Foundations for the current work date back to the earlier Finclad1 project (2002-2003).

The requirements management process is to ensure that we know the customer needs and that the solutions efficiently meet those requirements, thus increasing the final products value. Even though life cycle approach has become increasingly popular, an illusion of sequential process phases still dominates esp. in construction industry. In practice, due to the parallel nature of design and construction phases (and to some extent, even operation), requirements setting, updating and verification have to take place throughout the project.

Recently, the open international standards for building design information exchange have become more robust and more widely used. In particular, the International Alliance for Interoperability (IAI) is continuously developing the Industry Foundation Classes (IFC) open model based information exchange specification. The coverage of IFC product model has enlarged during past few years, and nowadays it contains project information related to, for example, actors and assets; elements and spaces; structures and zones; systems and environmental impacts; schedules and costing; equipment and work plans; associated documents and classifications. Focus has also started moving towards service life and requirements management. This shift is expected to enable and motivate developers and practitioners moving towards consumer driven process.

In the present IFC version (IFC 2x2) expressing product requirements is supported in a modest way. However, it is evident that product model technology has developed to a level where extensive requirements management could be enabled. This progression leads to increased interoperability between customer needs and design solutions, by defining explicit “requirement”-objects and their relationships to design objects. The authors highlight though that there are still many open questions needing answers.

The results from Finclad2 project define classification for requirements managed in product model environment, as well as guidelines for their attachment to IFC product model design object. It is apparent that in this approach requirements are set in various levels, such as component, system, space, zone or building (or even project) levels. Traditionally, requirements have been captured on a very generic level (project or building), whereas in the Finclad2 case the target is on exterior wall level, which introduces challenges in linking of space requirements to wall properties and production planning; also, design application developers have challenges in including requirements management in their software. In result, a test environment for requirements management is created and set of requirements is exported in an IFC file.

Keywords: Requirements management, classification, IFC, interoperability

1. Introduction

Finclad2 project was launched at the beginning of 2004. It is an enterprise driven synthesis combining two bridging projects, led by Finnish Constructional Steelwork Association (FCSA) and Tekla Corporation, respectively. Results introduced in this paper are a part of a research activity carried out by Technical Research Centre of Finland (VTT) and belonging to the FCSA part. Foundation for the current work was laid in Finclad1 (2002-2003) project, which among other tasks, described common cladding wall structure types and the use of IFC specification for exterior walls, as well as listed the basic requirements to be considered [1].

The goal of Finclad2 is to implement previously described wall structure types as adaptive objects to software. Firstly, the purpose is to take advantage of the previous development results in practice. Secondly, the project emphasizes production chains by offering means to exploit product models more efficiently, especially for capturing and managing requirements during a project.

This paper discusses the issues of requirements management in general, and possibilities of model based design and requirements management using IFC product model in particular. Main goal is to find solutions on cladding wall structures and how their properties can be managed and how the process can be supported by ICT tools and model based information exchange/sharing, through the life cycle of buildings.

The final outcome of the project will be presented at the end of year 2005. Finclad2 is financed by Tekes, the National Technology Agency of Finland, and the enterprises participating.

2. Requirements Management

2.1 Requirements Management in Building Process

Requirements management is targeted to increasing final products value; it is a process assuring that the building performs as expected or better in its intended use. Overall goal is ensuring customer satisfaction. It is described in numerous sources as a set of procedures helping to understanding, modelling and analysing the needs of users and other participants' processes, and tasks in a realisation process towards a common vision [2, 3, and 4]. Life cycle view has become stronger and the ideology is supported by various practices, such as value management and commissioning, that are used for assuring convergence of building performance towards user needs set in the beginning.

In construction industry a false illusion of sequential process phases still dominates. Clear indication that is also understood in practice is parallel nature of design and construction phases. Kiviniemi represents difference of sequential and parallel process view clearly (see Figure 1) [5]. In this context the requirements management practices need improvements; the procedure evolves during project execution and at the moment the practice doesn't support rapid changes taking place in projects, especially during design phase.

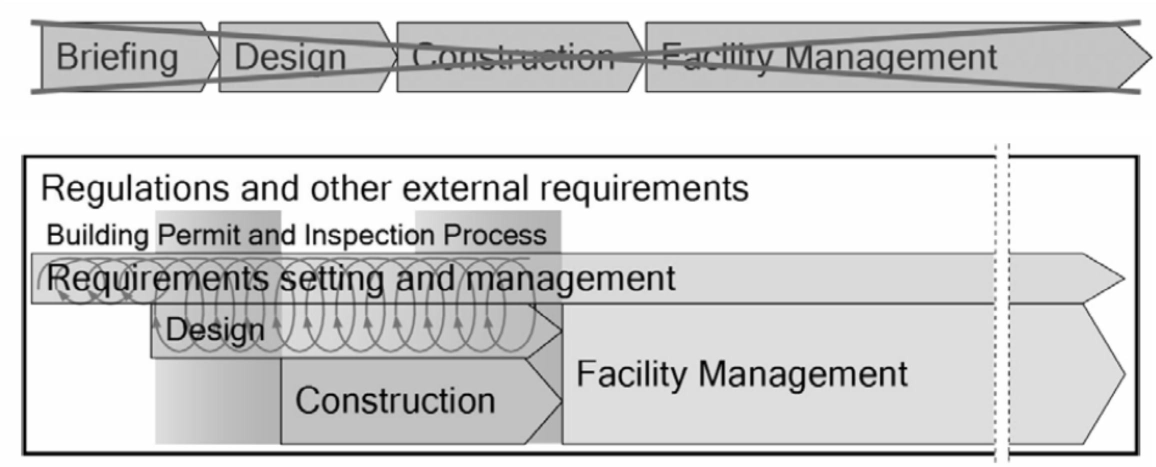

Figure 1: False illustration of sequential process and more realistic parallel process view (Kiviniemi 2005).

General requirements management process phases are:

1. Requirements setting,
2. Requirements updating
3. Verification of the requirement realisation in practice.

Buildings are unique solutions, each having individual requirements. Careless requirements setting increases risk of ending up in significant problems later. If the purpose of requirements management is not understood correctly, it might be seen as a mandatory task producing nothing, which is not the case. Actually, great potential lies in requirements management: it should be seen as an intermediate tool between user and design team, helping to reach satisfactory end result. The most critical step should be capturing user requirements instead of getting straight into technical solutions. Users look for a building that is customisable to their operations, not vice versa. Far too often requirements are lost or misinterpreted during design and construction phases. Figure 2 describes the possibilities of loosing or adding value. Practitioners should be able to offer new and innovative solutions along the building process; at the moment tools enabling this are still lacking.

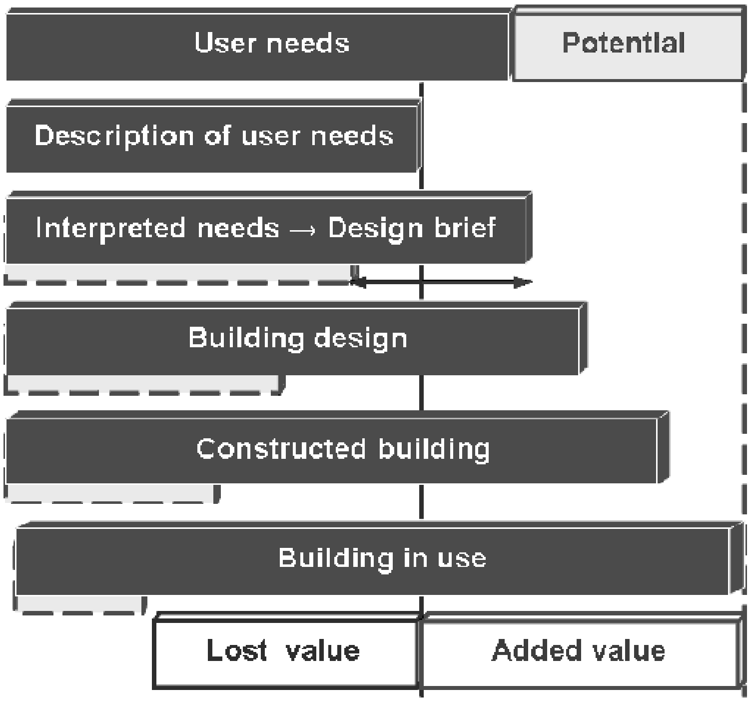

Figure 2: Potential of Requirements Management [6].

There are many kinds of problems existing; such as [7]:

- Communication problems (between process phases and in connection to users),
- Lacking of a systematic and standardised data transfer,
- Binding strength of requirements and design solutions,
- Inadequate change management practices,
- Insufficient verification practices

Change from prescriptive approach to performance based approach is taking place. Prescriptive approach describes first building parts and attributes and comes backwards to requirements (technical solution oriented). Performance approach specifies requirements for building parts and then various solutions meeting these conditions are provided by designers [8].

2.2 Requirements Management in Exterior Cladding Walls

Investigation of current practises in requirements management was carried out. Since the current development efforts are directed towards model based design, the ProIT process model [10] was analysed and the essential feedback gathered from participants was projected on it. Figure 3 describes main information flows in current process and it is intended to visually express certain bottlenecks and weak spots. Main processes are: 1) Architectural design 2) Structural design 3) Manufacturing 4) Installation 5) Use and maintenance.

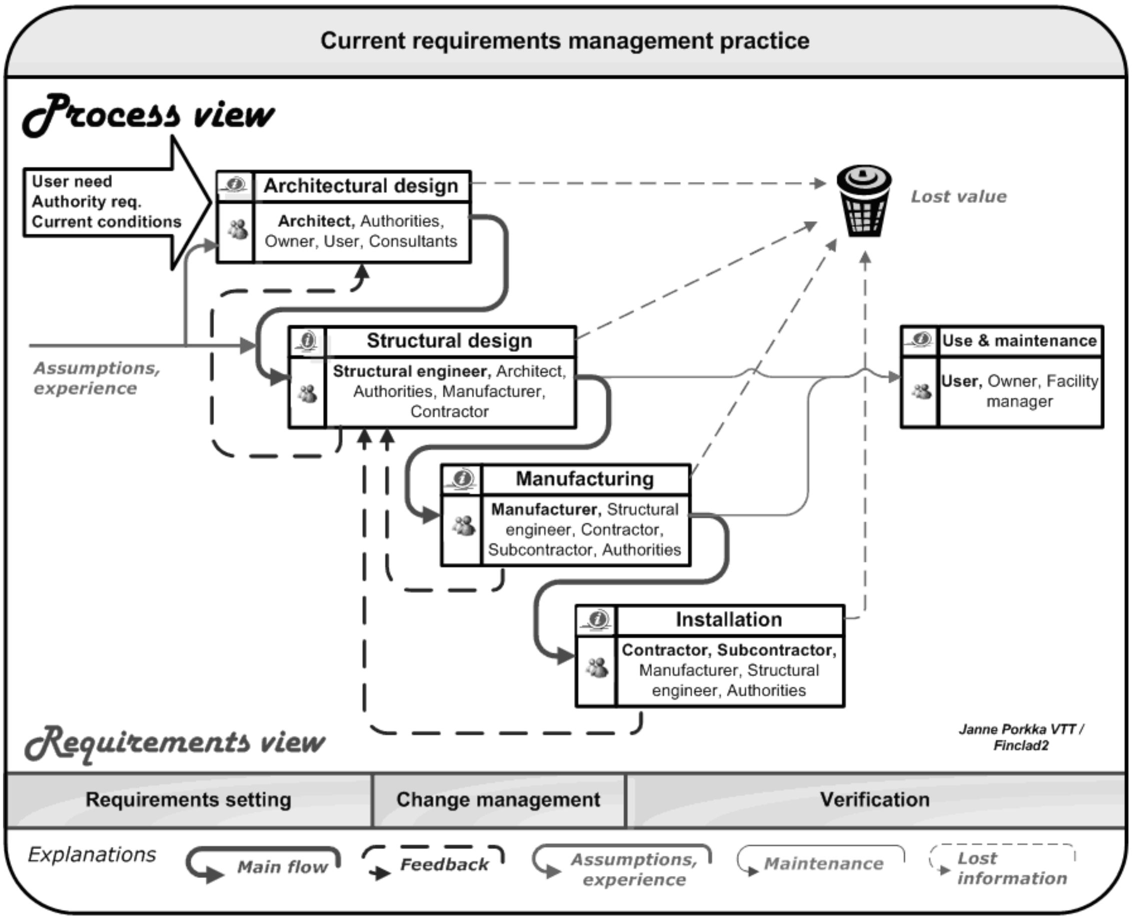

Figure 3: Current requirements management practice in Finland according to cladding walls.

Nature of requirements setting is consistent; process goes from general level towards details and specifications. Practices of requirements management by individual participants vary greatly. Even with the most organised practitioners improvement needs exist. When individual participants express requirements differently– the overall process with interfaces to many participants gets even more problematic. Main bottleneck in current requirements management practice is lack of standardisation and large part of requirements never get documented during architectural design. This knowledge reserve is covered by tacit knowledge - or leads to lost value.

Architectural design captures main requirements set by owner, users, authorities (standards, specifications) and current conditions (location, surroundings). Finnish construction practise is rather well standardised and therefore large share of requirements come directly or implicitly from standards such as National Building Code of Finland [9]. Only a limited group of owners are willing to put more effort in setting requirements; additionally, user requirements are described rather in every-day-language than technical terms. In detailed cladding solutions architects rely on experts and consultants. Requirements are expressed in drawings and textual documents, such as design brief. Bottleneck in current practice is data sharing between architectural and structural design. Large part of the requirements remains only in architects mind and do not reach the structural design and later phases. From experts point of view information is partly considered too obvious and standardised way of sharing requirements is missing.

Structural design provides detailed requirements for product manufacturing, installation and also to use and maintenance phase. As described earlier, the starting point is the weak spot. Shortage of requirements in kick-off increases iteration work and leads to assumptions; this also increases the risk of ignoring essential requirements. Overall, the nature of requirements management in structural design evolves from requirements setting to change management and finally to verification. Standard on how requirements should be described is missing, and current practise vary by case.

Manufacturing and **installation** have very specific requirements. Manufacturing produces also requirements back to structural design, and further to installation. It requires active cooperation with structural engineer, especially when making iterations on change management. Phase includes also detail and product reviews. In installation, the end result is verified against the set requirements. Installation is considered as a task producing feedback to structural design on work sequences; the working order must be considered already in structural design, and therefore details of installation must be considered at early stage.

Overall, the weak spots detected in current practice are:

- user requirements capturing,
- communication between architectural and structural design,
- the quality of set requirements, standardisation lacks,
- specific manufacturing and installation requirements and maintenance manual,
- change management and verification of set requirements and end result,
- knowledge reserve among stakeholders – tacit knowledge (or lost value).

A lot of headache is caused by the gaps between participants: fragmental data exchange leads to rework and confusion. Other development needs are seen in the learning process; past mistakes should lead to immediate development and to process changes if needed. We should consider methodical development possibilities, such as commissioning and performance based approach. Both highlight the continuous requirements management as a development enabler.

3. Model Based Requirements Management

Recently, the open international standards for building design information exchange have become more robust and widely used, in particular the product model specification for AEC/FM, the Industry Foundation Classes (IFC) [13]. The IFC is developed and published by the International Alliance for Interoperability (IAI), established in 1995 and currently operating as a not-for-profit company in the UK, with 10 active chapters globally (about 500 member companies and other organizations in these chapters). The mission of the IAI is to enable ICT interoperability, based on open specifications, in the AEC/FM industry processes throughout the building lifecycle. The IFC is a specification for data exchange and information sharing between computer applications used by project participants in design and construction as well as operation and maintenance phases.

The first set of IFC was published in 1998 as Release 1.5; current version IFC2x2, released in 2003 utilizes extensibility mechanism by which new concepts can be added to support areas not previously existing in the IFC model (e.g. structural engineering and steel construction were introduced in 2x2); a new release (IFC2x3), extending the IFC model in the same manner as IFC2x2 did, is expected in spring/summer 2005 (with some improvement in requirements management).

The IFC specification aims to cover information in all aspects of buildings and processes encountered in their production and operation; the IFC product model may contain information related to e.g. actors, assets, elements, spaces, structures, zones, systems, environmental impacts, schedules, costing, equipment, work plans, associated documents and classifications. At the moment the focus of development is moving towards life cycle management, meaning improvements on requirements management support also. In practise this would mean that in addition to ‘conventional’ design objects, such as *IfcBuilding*, *IfcSpace*, *IfcWall* etc., also objects representing requirements as *IfcConstraint* could be defined independently and associated to those design objects as (and when) appropriate. The requirement objects would also have capability of being classified (an essential feature, as discussed later) and having owner and history, as well as relationships to other requirements.

Many research and development efforts are aiming to take advantage of product model technology. Finnish ProIT project has targeted to improvements in practice [10]. It declares information management of whole life cycle where data management takes place in process by product models. Product models in different phases suggested in ProIT are:

- requirement model
- design model

- planning model
- as-built model
- maintenance model

It's evident that model based approach has more strengths than weaknesses - though application interfaces need to be developed to support the exchange cases. For requirements management this means that early phases of projects are seamlessly connected to later ones. Industry is provided with means to set more detailed requirements separately for certain types of cladding walls. Overall target is to provide way to transfer data in same format through the architectural and structural design further to manufacturing and installation as well as use and maintenance - with requirements and verification data. In this context individual requirements are better managed and verification of received quality improved.

3.1 Combining Requirements from Authorities and Users

In this context a user means relevant project stakeholders, like occupants, owners and financiers of the building [11]. Requirements management in the building process deals with unique solution and diversity of participants. There are certain mandatory requirements steering the process, such as laws, standards and directives set by authorities. Amongst requirements there are also recommendations and rules that can be waived. Mandatory requirements contain basic conditions such as safety, conformity, performance, functionality and usability. Another group of requirements is optional requirements, such as user requirements.

During the requirements management process the set of user requirements is adapted to authority requirements. The compliance of design with the requirements should be verified constantly during the project. Participants should be involved in project from the very beginning; other enabler is functional communication. Purpose of requirements management is establishing a complete, consistent and unambiguous requirements specification [2]. There are certain characteristics portraying good requirements, such as being complete, unambiguous, consistent, feasible, solution neutral, traceable, necessary, used for right purpose, concise, correct and verifiable [10].

3.2 Considering Stakeholders

Nature of construction projects includes large variety of participants in decision making. It is very common that opinions vary greatly. In these cases judging methods and decision support tools are needed. It's suggested that the ranking of stakeholders' opinions is based on three attributes - power, interest and proximity [3]. This means that participants with high ratings are very likely to have their requirements accepted. Using the same analogy, stakeholders with low ratings don't have as strong influence to the performance of final product. Various stakeholders also see the requirement management effort differently – some like it while others see it as a disturbance to their routine work [3]. In cladding walls the requirements are mostly transferred simultaneously with drawings. It’s important to name the responsible people for requirements management. Also judging methods for prioritising requirements should be defined. At the moments standards in data transfer in requirements management are lacking, therefore actions of change management should be clarified.

3.3 Temporal Progress of Requirements Management

Phases of requirements management are described in Figure 4. In the beginning the emphasis is on requirements setting. After setting of requirements the overall process starts finding technical solutions and emphasis evolves towards change management and verification. The possibility to influence the end result is biggest at the project start. This is also the period when the practitioners have the best possibilities to effect the costs. Owners may allow certain investment cost for cladding walls per square meter; yet the solution must fill certain other requirements such as energy efficiency in buildings life cycle. Therefore, the most of the requirements management effort is committed to projects two first phases, architectural and structural design. Effort should diminish after these phases and change nature to change management and verification. The cycle defined in Figure 4 is done multiple times while adjusting requirements management; nature of setting requirements is consistent.

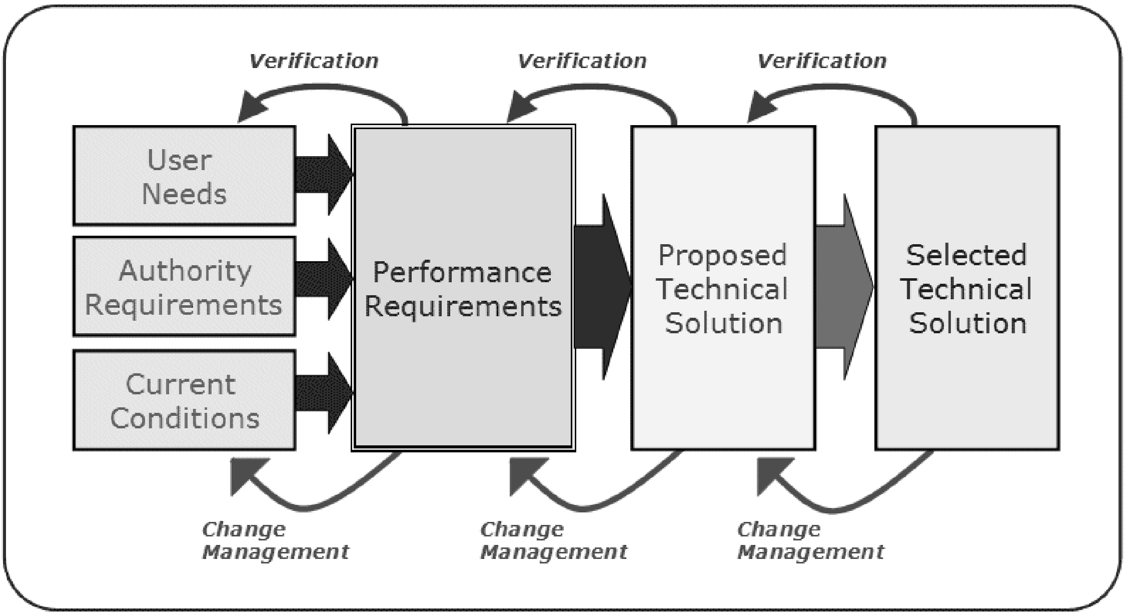

Figure 4: Requirements management process in performance based building [6].

3.4 Detecting Hierarchy of Requirements

Hierarchy of requirements means in this context the requirements classification. Classification is the way how the large information content can be managed. During Finclad2 project the requirement classification for exterior cladding walls, VTT ProP® Finclad2, was specialised form the general VTT ProP® classification. Classification contains structural description of requirements, expressed by categories such as safety and adaptability (see Figure 5) and individual requirements placed under these categories. One of the categories, adaptability is opened in Figure 6. Classification is important for meaningful data transfer between applications. It is also a guideline for producing complete and consistent information for later project phases; classification expresses the data in a form understood by all participants.

VTT ProP® Finclad2 CLASSIFICATION	
A CONFORMITY	**B PERFORMANCE**
A1 LOCATION	B1 INDOOR CONDITIONS
A1.1 Site characteristics	B1.1 Indoor climate
A1.2 Transportation	B1.2 Acoustics
A1.3 Impact on surroundings	B1.3 Illumination
A2 SPATIAL SYSTEMS	B1.4 Vibration conditions
A3 SERVICES	B2 SERVICE LIFE AND DETERIORATION RISK
C COST AND ENVIRONMENTAL PROPERTIES	B3 ADAPTABILITY
C1 LIFE CYCLE COSTS	B4 SAFETY
C1.1 Investment costs	B4.1 Structural safety
C1.2 Operation costs	B4.2 Fire safety
C1.3 Maintenance costs	B4.3 Safety in use
C1.4 Demolition and disposal costs	B4.4 Intrusion safety
C2 ENVIRONMENTAL PRESSURE	B4.5 Natural Catastrophes
C2.1 Biodiversity	B5 COMFORT
C2.2 Resources	B6 ACCESSIBILITY
C2.2.1 Energy consumption	B7 USABILITY
C2.2.1.1 Non-renewable energy consumption	**D PROCESS**
C2.2.1.2 Renewable energy consumption	D1 GENERAL INFORMATION
C2.2.1.3 Process energy consumption	D1.1 Collaboration
C2.2.1.3.1 Process electric energy	D1.2 Participants
C2.2.1.3.2 Process fossil energy	D1.3 Materials
C2.2.1.3.3 Process bio-energy	D2 BRIEFING
C2.2.1.4 Transportation energy consumption	D3 DESIGN AND CONSTRUCTION
C2.2.1.5 Feed stock energy	D3.1 Design
C2.2.1.5.1 Feed stock fossil energy	D3.2 Construction
C2.2.1.5.2 Feed stock bio-energy	D3.3 Tolerances and dimensions
C2.2.2 Raw materials	D3.4 Quality assurance
C2.2.2.1 Non-renewable raw materials	D4 MAINTENANCE AND REPAIRING
C2.2.2.2 Renewable raw materials	D4.1 Maintenance
C2.2.2.3 Hidden raw material flows	D4.2 Repairing
C2.3 Emissions	D4.3 Replacement
C2.3.1 Emissions to air	D5 DEMOLITION AND DISPOSAL
C2.3.2 Emissions to water	D5.1 Demolition
C2.3.3 Process waste	D5.2 Disposal
C2.4 Specifications	D4.3 Recycling
	D4.3 Reuse

Figure 5: VTT ProP® Finclad2 classification.

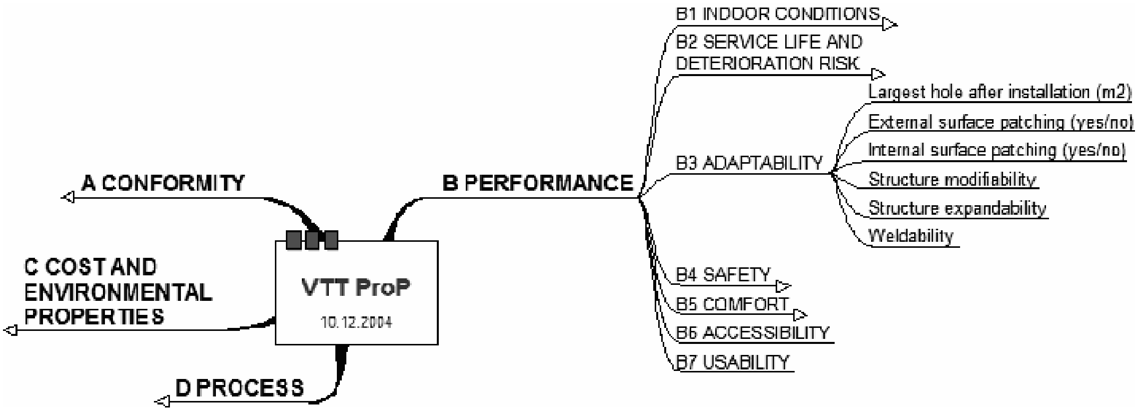

Figure 6: VTT ProP® Finclad2 classification, adaptability opened.

The nature in construction projects also is that level of detail changes during projects; from scheme in the beginning to details for the manufacturing. Biggest advantages of using classification are gained when early architectural design starts using classification and produces data in a form updatable in later phases. This procedure also helps to verify fulfilment of user requirements. Hierarchy of requirements is different from building model hierarchy or configuration which can be set up in various ways, e.g. as: building level, zone, space, system, element, component and property.

3.5 User Interface to Software

Linking model based technology and requirements management offers new possibilities for software development. Imagine an architect or structural designer viewing requirements parallel to actual design and verifying that everything is in order. Development of requirements management features should also be remarked in the next generation quality assurance systems. But before model based technology can be utilised in this respect, the appropriate data structures must be built into design systems and interfaces must be developed. At the moment this is still lacking; an illustration by a user interface mock up was presented by Kiviniemi as a link from CAD software to requirements setting [5].

4. Conclusions

Building process has been analysed with respect to present requirements management in exterior cladding wall models. Appropriate techniques and reference models for this purpose have been selected. Overall, the process deals with many problematic issues and at the moment combining requirements management with model based information technology is rather unexplored field, but product model technology is very promising for future development in requirements management procedures.

In general, it is often remarked that complicated system is the main limitation of wider exploitation. According to requirements management, a user friendly and understandable systematic structure is brought to practice by classification. For the case of cladding walls, new performance based classification, VTT ProP® Finclad2, has been introduced at the national level; the model based exchange specification is using IFC, with eventual additions as appropriate. Requirements representation in IFC model, as well as the classification is part of VTT task report (to be published).

The various participants and ICT tools used by them in activities concerning requirements are identified. At the moment the field of requirements management lacks appropriate tools, especially model based ones. Requirements management can form the basis of specific software or it can support larger content, such as guide designers as part of a modelling tool.

The target process for the future is capturing requirements, verifying satisfaction and thus increasing the quality and value of the product. A corner stone of the target process is highly semantic interoperability between various applications - enabled by product models.

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Section IV

Development and Evaluation of ICT Systems

Towards Web-based Learning System for Engineers Integrated with Problem-based Learning (PBL) Approach in Construction

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Abstract

In order to enhance the e-learning for engineers participating in construction projects, it is necessary to provide these engineers to a learning platform to study and understand how the construction operation and important events concerning about construction projects in advance before or during the construction execution. The online use of the system and project discussions help the engineers to relate better their previous academic knowledge to “real-life” problems, enhance their creativity, and increase the level of retention of the new knowledge acquired. Future enhancements and learning possibilities are discussed with the use of additional capabilities of information technology. Integrated with the application of Problem-based Learning (PBL), the e-Learning system can provide the engineers with an active role in learning and to allow the engineers to take responsibility for learning. The e-Learning system has integrated different disciplines and input from the project managers, engineers, and instructors of different disciplines. This system includes hypertext links to past experience, knowledge and stratified information including text, graphics, and videos. The e-Learning system presents a teaching platform that enables junior engineers to learn about construction phases of a construction project. Main contribution of this system are as the following; (1) Provide safety learning environment (2) Maintain and manage effectively the past knowledge and experience from past projects; (3) Reduce the cost and time of training and education; (4)Overcome the time and space

barriers of learning. Finally, the efficiency of the proposed system is demonstrated through case examples.

Keywords: E-Learning; problem-based learning; knowledge management; construction project.

1. Introduction

E-learning refers to any form of learning delivered or supported by the use of web-based technology or other electronic media. Compared with traditional classroom learning, e-learning has shown its advantages by its nature of flexibility, accessibility and convenience to learners. Given the broad deployment of network technology and increasing on-line communication in teaching and learning, there is an urgent need for a guidance on web-based instruction. From a combined perspective of constructivism and semiotics, e-learning is regarded as a process of Knowledge Management (KM). Many organizations are now engaged in knowledge management efforts in order to leverage knowledge both within their organization and externally to their shareholders and customers (Malhotra 2000, 2001). Knowledge management in the construction phase mainly deals with the process of creating value from construction operation, organization to company knowledge. Valuable knowledge can be available in different forms and media, such as in the mind of experts, in operation procedures, and in documents, databases, intranets, etc.; however, knowledge management in the construction phase of projects aims at effectively and systematically collecting and sharing the experience and knowledge of the project by web-based and intranet technologies.

Problem-based learning (PBL) is a teaching strategy that applies complex real-world problems to introduce concepts to students. PBL got its start in medical education and is now used at most medical schools (Hendley 1996). Integrated with PBL concept, the reuse of information and knowledge from past projects enhance learning quality during the construction phase of a construction project. By sharing experience and knowledge, the same and similar problems do not need to be solved over and over again. To improve the learning quality for engineers special in practice, this paper provides web-based learning system for "lifelong" learning and applies techniques integrated with PBL concept for engineers. Learning environment give engineers freedom to perform learning from different paths. In this way, engineers are put in the centre of a learning process, and construct knowledge through their own experience. Based on the construction project characteristic, the specific course - Taiwan Expressway Project is chosen to be an example for illustration. The outcome of our work is expected to be applicable for e-learning platform in construction practice.

2. Problem Statement

Construction projects are intricate, time-consuming undertakings. Usually, construction projects are typified by their complexity, diversity and by the nonstandardized nature of their production (Clough 2000). Professional competency in project management is attained by the combination of knowledge acquired during training, and skills developed through experience and the application of the acquired knowledge (Edum-Fotwe and McCaffer 2000). During the construction phase of projects, one of the improvements for construction management is to share experiences amongst engineers, which helps prevent mistakes that past projects have encountered already. Reusing experience also avoids problem-solving from scratch, i.e., already solved problems do not need to be solved over and over again. However, there are no suitable platforms to assist senior engineers or experts with sharing and collecting their know-how and experiences when general contractors execute the project. This is a major loss for general contractors who do not preserve the know-how and experiences of senior engineers and experts. When these engineers and experts finish the projects or leave the company, they usually take the domain knowledge with them and leave little or nothing for the projects or the company. In the view of knowledge management, these know-how and experiences of construction engineers and experts are the most valuable because they not only need manpower; they also require major cost and time to be accumulated.

3. Research Objectives

The main purpose for conducting this research is to develop a Construction Problem-based Learning e-Learning (ConPBL learning) system for general contractors, to provide knowledge exchange and management service in the construction phase of a project for the reuse of domain knowledge and experience in future and other related projects. Usually, it is possible for general contractor to execute similar or same projects. Therefore, problems in executing those projects can be considered to refer and learn for other similar projects (see Fig 1) Thus the capture, transfer, reuse, and maintain of the construction project knowledge are critical (Kamara et al., 2002). Knowledge management in the construction phase of a project is a knowledge-intensive organizational environment where knowledge creation has critical importance for general contractors. To be competitive, a general contractor has to make innovative use of knowledge created and accumulate through project activities, and share it across the rest of other relative projects. Engineers and experts participating in projects act as knowledge workers facilitating the collection and management of knowledge between current and past projects. In order to apply knowledge management to construction projects, the process and content of working construction knowledge need to be modified because of construction project characteristics. With the evaluation of the case study on the Taiwan highway project, the results show that the ConPBL learning system is effective in sharing the knowledge for a construction process. The case study also highlights the need for improvements to knowledge management and exchange platforms.

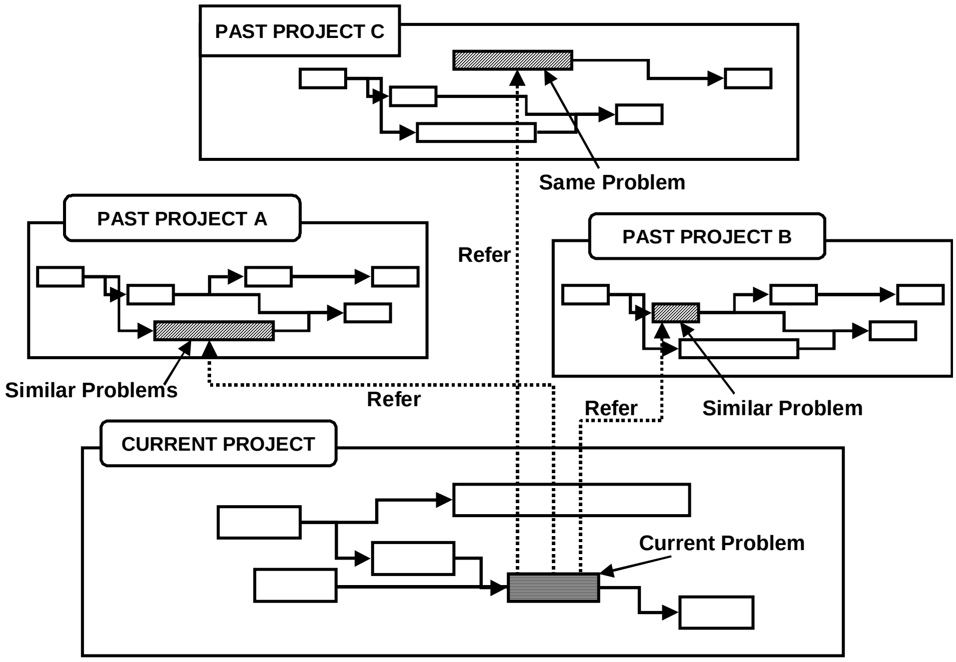

Figure 1 Problem-based experience management used in the construction phase of a project.

4. Knowledge Management in Construction

In construction projects, knowledge management is a discipline that promotes an integrated approach to the creation, capture, access, and use of a profession's domain knowledge on products, services and processes. During the construction phase of a project, most project-related problems, solution, experience, and know-how are in the heads of individual engineers and experts. Implicit knowledge usually is not documented or stored in a system database. To reuse the knowledge in other projects and also preserve it as corporation property, how to capture the implicit knowledge and make it become available as explicit knowledge is important in the execution of knowledge management in the construction phase. Experience, problem-solving, know-how, know-what, and innovation are created in the construction phase of any project. By practicing knowledge management, tacit knowledge can be reused for other projects and speed the improvement of operations in the construction phase. Undoubtedly, tacit knowledge is corporate property.

Usually, knowledge content in the construction phase of a project can be classified into two broad categories; tacit knowledge and explicit knowledge. Tacit knowledge is personal, context-specific knowledge that is difficult to formalize, record, or articulate; it is stored in the heads of people (Hart 1992). The tacit component is mainly developed through a process of trial and error encountered in practice. Tacit knowledge is personal knowledge embedded in individual experience and is shared and exchanged through direct, face-to-face contact (Tiwana 2000). Tacit knowledge can be communicated in a direct and effective way. By contrast, acquisition of explicit knowledge is indirect: it must be decoded and re-coded into one's mental models, where it is then internalized as tacit knowledge. Explicit knowledge that is formal knowledge can be codified and transmitted in a systematic and formal language; documents, database, website, etc.

It can be found in the documents of an organization: reports, articles, manuals, patents, pictures, images, video, sound, software, etc. It can also be found in organizational documents such as organizational charts, process maps, mission statements, domains of experience, etc.

Explicit knowledge is easier to collect and manage during the construction phase of a project because the information and knowledge are available in document form. With document management, information and knowledge can be preserved and managed effectively without explicit knowledge extraction. Therefore, explicit knowledge is easier than tacit knowledge in the field of knowledge management. However, the main problem in the view of tacit knowledge is how the tacit knowledge can be extracted into structured information and unstructured information effectively. After the extraction of tacit knowledge, the explicit information can be maintained and managed with the assistance of document management tools.

5. Problem-based Learning in Construction

Problem-based learning emphasizes learning by doing. It also provides a motivating context for learning. In construction projects, junior engineers are given a real-world problem similar to those they would face as professionals. They take ownership of the problem, and the problem solving process. Instructors (senior engineers), in turn, take the role of a cognitive coach. A pedagogical goal of PBL is to help junior engineers develop their own problem-solving skills, rather than tell them how to solve the problem.

The literature on problem-based learning in engineering education suggests many educational and professional benefits of this approach (Hendley 1996; Dutson et al. 1997; Johnson 1999), which support the findings of other professional literature (Albanese and Mitchell 1993; Chen et al. 1994). The benefits of PBL are examined here, focusing on five main themes—applicability, problem solving, active learning, motivation, and professional skills (Anne 2003).

In order to reduce the training time for junior engineers participating in construction projects, it is helpful to provide these engineers with a learning platform to study and understand which problems the construction process happens and related solutions concerning problems. With the application of PBL approach, the problems and solutions from past projects can be reused and learned with junior and senior engineers. The integration of PBL and knowledge management in construction is shown in Figure 2.

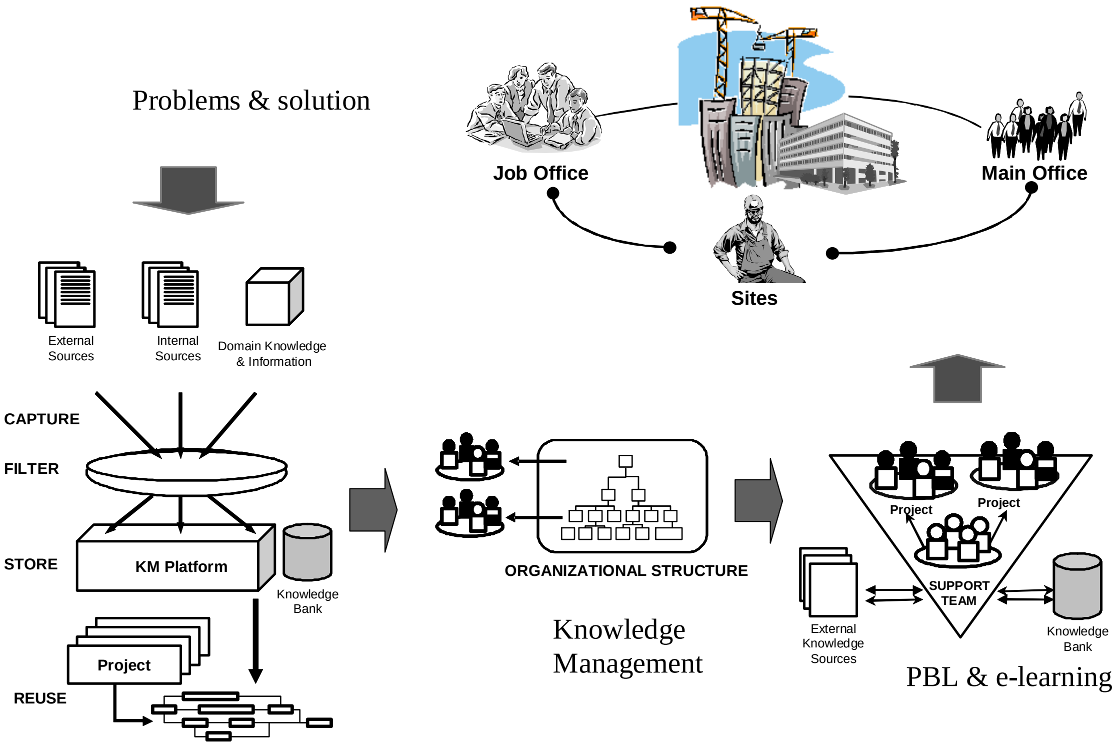

Figure 2 Construction knowledge management integrated with PBL Concept

In construction projects, the knowledge includes both tacit and explicit knowledge. In terms of explicit knowledge, project-related information or knowledge usually include specification/contract, reports, drawing, change order and data. Actually, each project does not contain one-to-one information or knowledge because some of them belong to project-oriented information. In contrast, tacit knowledge may include process records, problems-faced, problems-solved, expert suggestions, know-how, innovation, and experience notes. The relationship of current and past same or similar problems is important for users to link related information and knowledge together. Furthermore, not only the information and knowledge of the current project can be applied, but also same or similar solutions of past projects can be referred to as experiences are recorded. When experts or engineers have problems they cannot handle in the project, they may learn the solutions regard to the same and similar problems. Figure 3 shows e-learning environment designed by PBL concept.

With the assistance of e-learning and knowledge management, junior engineers may acquire the know-how and experience directly from past projects, reducing the time and cost of training. By sharing past experience and knowledge, the same and related problems in executing projects do not need to be solved over and over again. Furthermore, the junior engineers can understand how the construction process works more quickly and easily by utilizing an e-learning platform.

In order to enrich the knowledge bank in the system, the system is designed to encourage all engineers and experts to submit their domain knowledge and valuable experience to the knowledge bank. Traditionally, companies included mostly numeric, structured data in their data warehouse. From this point of view, decision support systems are divided into two camps: data warehouses deal with structured data; knowledge management involves unstructured data (Ponniah 2002). It is a need to integrate both structured (such as data and text) and unstructured information (such as image, video, audio, image, and drawing) in the knowledge bank for further decision-making and reference. The main purpose of a knowledge bank is to provide the rich source of content concerning all projects and gather project-related explicit information and tacit knowledge together for involved engineers and experts.

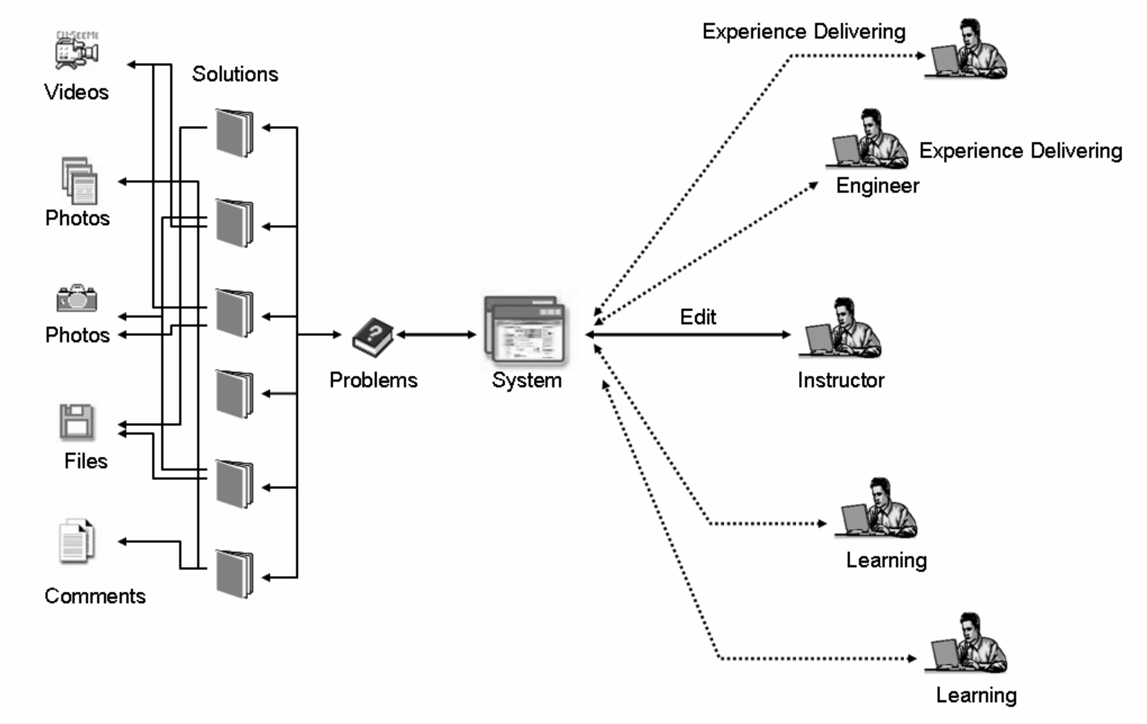

Figure 3 Problem-based Learning (PBL) E-learning for knowledge management.

6. System Development

The system is developed and implemented with an interactive e-learning platform using web-based technology and knowledge management concepts. The multimedia courseware provides junior engineers with illustrations specific to operation procedures using web technology. In addition, digital films record the whole construction operation. The digital films helps the junior engineers understand the process easily and effectively. Furthermore, digital films are recorded and clearly describe the progress and operation of the construction operations. In other words, junior engineers can access the digital illustrations and digital files for each activity or event in the system. Of course, those e-learning materials must be confirmed before being published in the system.

In construction projects, most project-related problems, solutions, experiences, and know-how are recorded into multimedia-based content. Also, multimedia systems are particularly suited to interactive applications since they allow huge collections of visual media, text, and other data to be stored in a single digital document and accessed easily and quickly. Usually, implicit knowledge is not documented or stored in a system database. It is important to capture the implicit knowledge and make it available as explicit knowledge. In this study, most tacit knowledge will be recorded as multimedia-based content for knowledge and experience exchange during the construction process. In other words, the valued knowledge can be collected and edited into explicit knowledge by the knowledge management team.

A detailed description of the ConPBL learning system will be given in this section. Figure 4 shows the system architecture. The server of the ConPBL learning system provides four distinct types of layers: interface, access, application and database layers, each with its own distinct responsibilities. The interface layer defines administration and end-user interfaces suited to his/her work. The users can access information through web browsers such as Microsoft Internet Explorer or Netscape Navigator. Administrators can control and manage information through the web browser as well as a separate server interface. The access layer provides system security and restricted access, firewall services, and system administration functions. The application layer defines various applications for information collection and management. These applications provide indexing, full text search, collaborative work and document management functions. The database layer consists of a primary SQL Server 2003 database and a backup database (also based on SQL Server 2003).

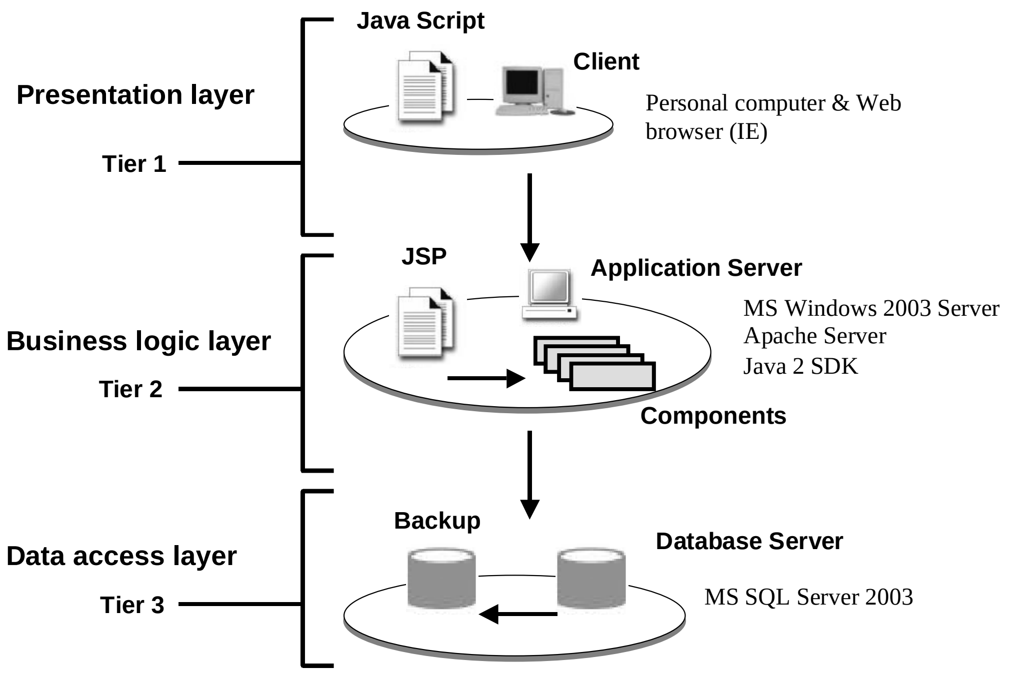

Figure 4 System architecture.

The ConPBL learning system services described in this paper are made available to all the participants of the company through a specially designed portal, which also serves as a messaging (mail) server for the company (organization). The portal is a key element of the proposed system and it consists of three content areas: public, member, and knowledge manager areas. The public area is open to anyone who is interested in the project. On the contrary, the project member and knowledge manager are restricted to members with password protection.

Since anyone can access information from the public area, it is a logical place for project managers (or developers) to utilize for public relations – to post project descriptions, news, announcement, etc. In the project member area, project members can use ConPBL learning services, such as messages, data, and files. Any information and knowledge concerning the projects can only be accessed by project members. Only knowledge managers have the rights to log onto the manager area, where they can access all information in the project server. Figure 5 illustrates the application of knowledge sharing in ConPBL learning system.

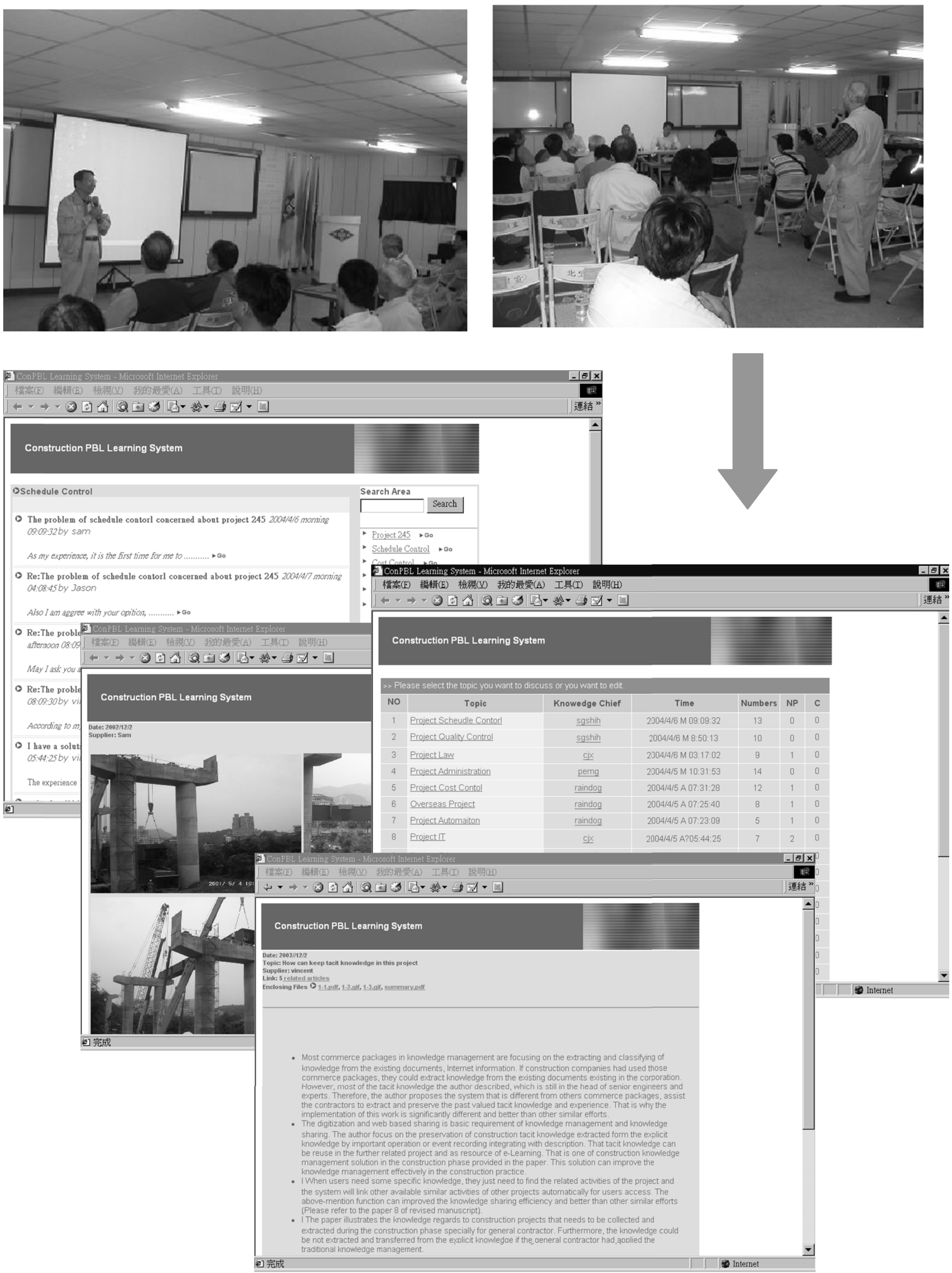

Figure 5. The application of knowledge sharing in ConPBL learning system.

7. Conclusions

The application of knowledge management for construction project in the construction phase is discussed in this paper. Also, the main purpose of this paper presents a construction Problem-based Learning (ConPBL learning) concept and system for general contractors as a knowledge-sharing platform. Construction Project-oriented knowledge management maps the valued information and knowledge into project units for a project during the construction phase. The development of the ConPBL learning System employing the integration of web technology with a portal is delineated and it has been illustrated through a case study in the Taiwan Highway Project. The ConPBL learning system is advanced at least in the following aspects: the ConPBL learning system enables gathering insight into the factors having impact on construction management activities; in turn this will help engineers share knowledge to improve operation performance. Junior engineers can interact with the computer so that they can understand the domain knowledge to prepare and participate in a construction project. In short, the ConPBL learning system is able to assist engineers by providing accurate and rich information for knowledge reuse and reference. The integration of knowledge management and web-based technologies appear to be a promising way to improve construction operation management during the construction phase of a project.

The collection of explicit and tacit knowledge for any project and non-project in construction projects allow engineers and experts to reuse most project-related knowledge/information during the construction phase. The content of the knowledge bank in the system not only provide the specific problem-solutions, but also support all area domain knowledge and experience from the projects. Although effort is required to update the explicit/tacit knowledge for various types of projects, the developed system will benefit construction management by (1) providing an effective and efficient computerized environment to assist knowledge management tasks, and (2) facilitating the implementation of a web-based knowledge management system pertinent to these activities in the projects. With the evaluation of the case study in the Taiwan expressway project, the questionnaire results show that a ConPBL learning system is effective in sharing knowledge for construction projects. The case study also highlighted the need for improvements to knowledge management and exchange platforms.

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Realising Electronic Purchasing in the Irish Construction Industry

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Abstract

The use of Information Communication Technologies (ICT) in construction purchasing has been sporadic and piecemeal. Very significant inefficiencies and problems still exist in both paper transactions and non-integrated electronic solutions. At the simplest level, the electronic transmission of business documents offers savings in paper and postage. By going a step further, businesses can make strides in communicating with their partners, at relatively low cost, through direct links between their computers. Existing ICT such as the Internet, Bar-Coding, Radio Frequency Tagging, Electronic Data Interchange (EDI), Electronic catalogs and Enterprise Resource Planning Software (ERP) have facilitated electronic commerce (EC) functionality within many business sectors. However, the adoption of such technologies in the Irish construction industry has been very slow with only limited evidence of their application. The results of a Proof of Delivery (POD) pilot project carried out by the Construction Information Technology Alliance (CITA) in 2004 indicates that significant cost savings can be achieved by trading partners by the adoption of existing technologies.

Keywords: Construction, e-commerce, information technology, procurement, purchasing.

1. Background

CITA is a collaborative organisation aimed at bringing together academia and practitioners, with a common purpose to promote the application of ICT in the Irish Construction Industry [1]. A Special Interest Group within CITA was formed in 2002 to consider specifically the administration involved in ordering, delivering and invoicing of building materials. CITA approached a number of interested parties within the Alliance to lead a proof of concept pilot project to show how costs can be minimised and efficiencies gained in the ordering, receipt and payment of construction materials by the effective use of ICT.

It is generally accepted that building materials account for up to 50% of all construction costs. In this field of business-to-business (B2B) interactions, there is a huge untapped potential for productivity gains. In Sweden [2], Finland [3] and in the UK [4], materials management has been identified as an area where significant cost savings could be made. Laage-Hellman and Gadde gave an account of the progress made by the Swedish construction company Skanska in its attempts at introducing EDI into its purchasing system. The cost of processing an invoice was found to be SEK 300 (approximately US$45). Laage-Hellman and Gadde concluded that this cost could be reduced by 90% by using EDI.

The purpose of this paper is to share the experience gained by the authors in carrying out a pilot study and to identify the main problems that exist with the current mainly paper-based process adopted in the purchasing of materials in the Irish Construction Industry. The authors conclude that the re-engineered solution proposed will explicitly deal with all the problems that currently exist.

2. Traditional Purchasing Practice in Construction

Purchasing procedures typically involve a paper-based communication process between the purchaser and supplier. Evidence shows that the construction industry is lagging behind other industries globally in adopting new technologies [5]. The process invariably commences with the sourcing of the materials. This typically involves site personnel requisitioning the project material requirements on a daily basis. Once a suitable supplier has been selected, the next step is to raise and issue a purchase order to the supplier. On delivery of the materials to site, a delivery docket is signed by the contractor and forwarded to head office as proof of delivery. Payment of the invoice is made following the matching of the invoice to the original purchase order and signed delivery docket. Kong et al identified the limitations of the traditional material procurement process [5]. As every step is reliant on input from one or more individuals, there are frequently problems in the process. For example, the requirements of the contractor are misinterpreted by the supplier, a docket goes missing, transcription errors occur, the invoice is not correct, the goods are not all delivered at the same time, the delivery docket does not match the order, payment is held pending matching of documents, etc. Any of these problems can add significant delay and cost to the process.

3. Available Technology

Technologies are in place to process electronic transactions more easily and at less cost than one can process paper transactions [6]. ICT is changing almost all functional aspects of a modern business in Ireland, particularly in industries such as financial services, travel and retailing. With the continued expansion of the Internet, EC provides unparalleled opportunities for businesses to bring greater efficiencies in transaction based commercial activities [7]. Technologies such as Automatic Identification (Auto-ID) and bar coding have become widespread within manufacturing, medicine and retail industries. However, the rate of adoption in other business sectors, such as the construction industry has been very slow and piecemeal [8]. Li argues that the benefits of ICT deployment are marginal, if simply imposed on an already inefficient construction process [9]. He argues that the processes should be redesigned to maximise the use of ICT. Hammer described how heavy investments in ICT in the 1980's delivered disappointing results, largely because companies tended to use technology to mechanise old ways of doing business [10].

4. The Pilot

4.1 Aims and Objectives of Pilot

The overall aim of the pilot was to prove that delivery data can be captured electronically and be acceptable as "Proof of Delivery" for the construction industry by use of readily available technology. The underlying objectives of the pilot project included: -

- To develop a clear understanding of how the existing purchasing systems operated in both contractor and supplier organisations.
- To confirm ICT operational systems and their current reliability in both the contractor and supplier organisations.
- To investigate the ease/constraints with which information can be captured from or added to contractor and suppliers existing purchasing systems.
- To test and confirm ICT handheld usability in a construction environment.
- To confirm productivity improvements and potential savings as a direct result of this pilot with both the contractor and the supplier.

4.2 Methodology

The methodology adopted for the pilot included five inter-related steps, involved: -

1. The vision/scope of the pilot,
2. proof of concept,
3. pilot itself,
4. evaluate pilot and
5. post pilot evaluation.

The methodology process is shown in Figure 1.

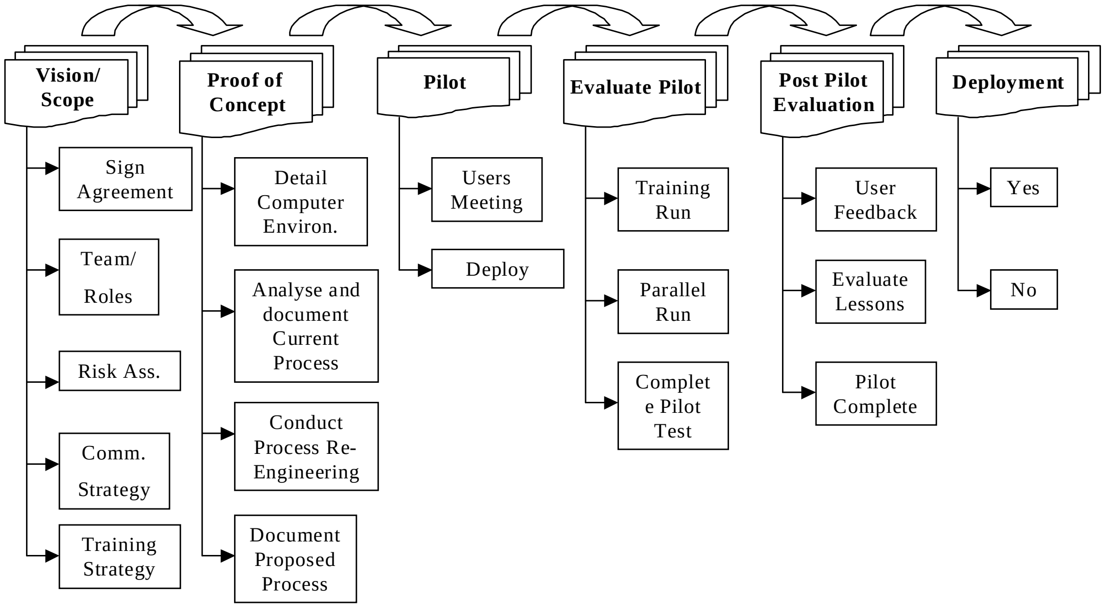

Figure 1. CITA Pilot Project Methodology

4.3 Pilot Team

The pilot team members principally included the lead author, main contractor, building supplier, ICT providers and an independent monitoring consultant, all of which were members of CITA. Figure 2 illustrates the communication relationship between the parties.

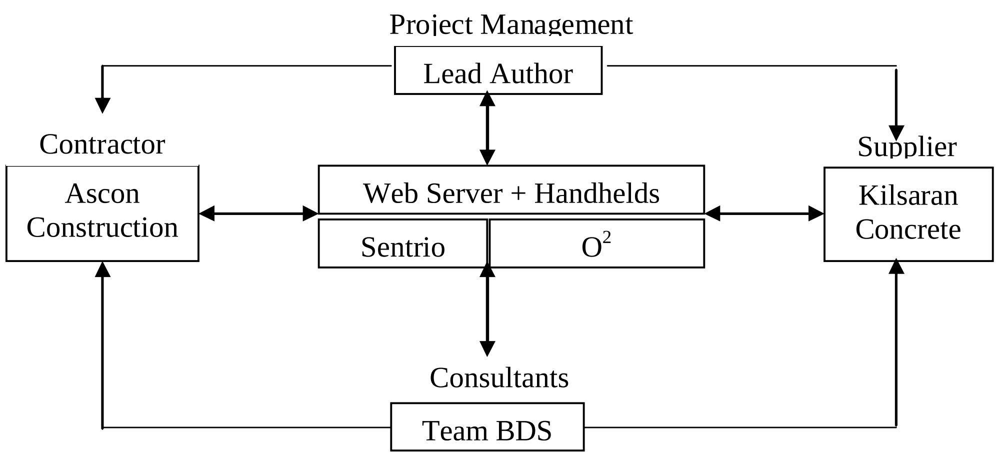

Figure 2: Pilot Team

4.4 Problems to be Addressed

The main problems encountered by the contractor and the supplier included very large volumes of paper generated in their purchasing processes; a significant amount of time spent in carrying out repetitive tasks such as scanning, photocopying, matching documents; inaccuracies in the ordering and delivery process and the degree of mislaid delivery dockets, leading to delays in payment and in many cases non-payment. Table 1 documents the magnitude of the documentation that are created annually within the contractor and supplier organisations.

Table 1. Estimates of purchasing documentation created by contractor and supplier

Pilot Contractor	Pilot Supplier
78,000 invoices per annum with an average of 5 lines per invoice	31,000 invoices per annum with an average of 20 lines per invoice
390,000 goods received notes per annum	1,250 invoice queries per annum
20,000 missing documents per annum	375,000 delivery dockets for scanning per annum
10,000 order amendments	

It was decided by the pilot team to approach the pilot project in two phases. The scope of Phase 1 sought only to address the delivery aspect of the purchasing process as illustrated in Figure 3. The precise scope of phase 2 would be decided following an evaluation and review of Phase 1.

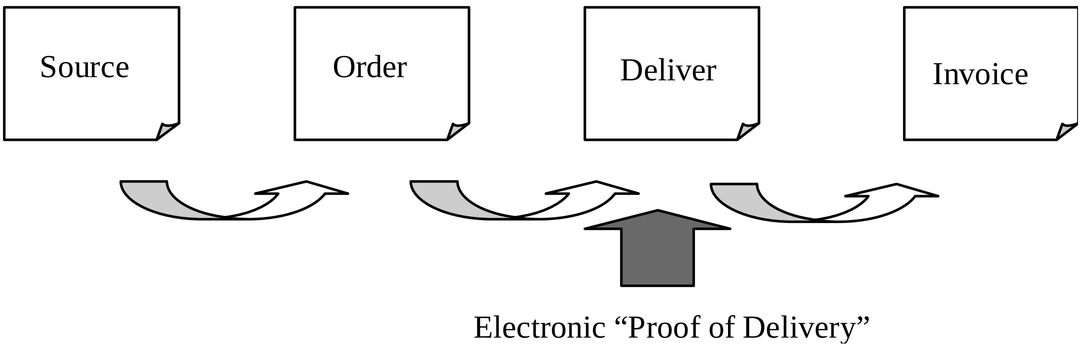

Figure 3. Focus of Pilot

4.5 Technology Landscape

The technology landscape selected for the pilot was a web-based solution, as illustrated on Figure 4. This allowed for the capturing of the POD on a handheld device. The ICT landscape adopted did not in any way require the contractor or the supplier to re-configurate their back-end ICT systems. The technology simply allowed for the purchase order to be captured on a mobile handheld device, which in turn allowed for the POD to be captured by way of a wireless connection on an independent website.

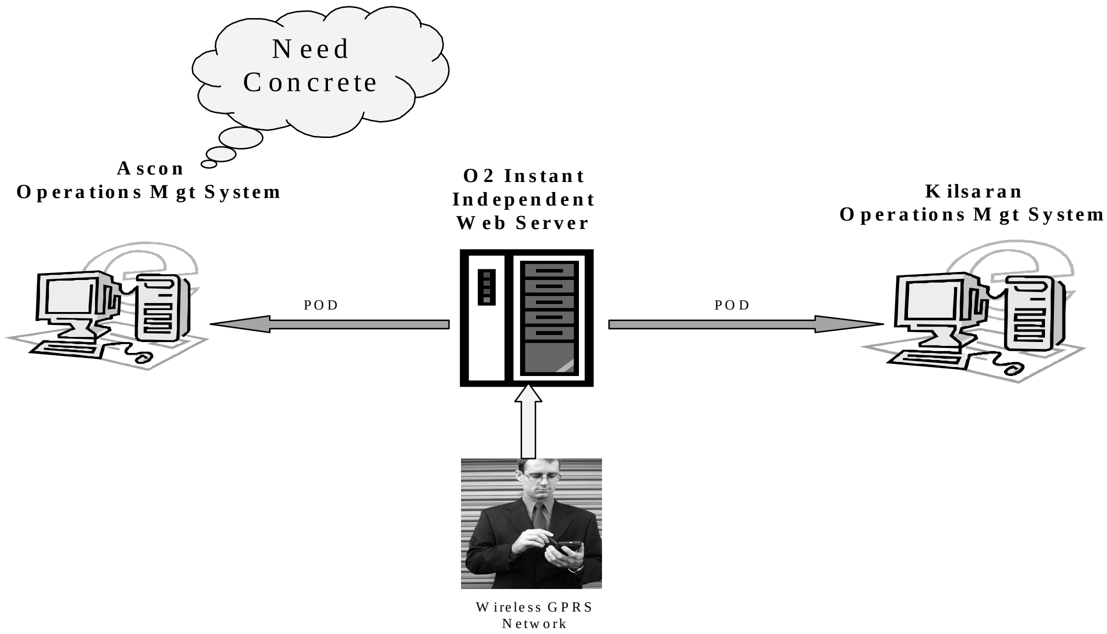

Figure 4. Technology landscape of Pilot for concrete supply

4.6 Pilot Process

A more detailed overview of the pilot process is shown in Figure 5. The pilot process commenced with the contractor calling-off material by phone call and confirming their request by use of facsimile. The supplier in turn generated the order details onto their ICT document management system and simultaneously onto the central web repository. Order details were then transferred onto a handheld device, which, on delivery to the site, were presented in an electronic format for signature on the device. Once signed the POD was instantaneously sent back to the central repository. This allowed both companies to check the delivery information and customer signature online. This enabled the parties to query delivery information using the central web application.

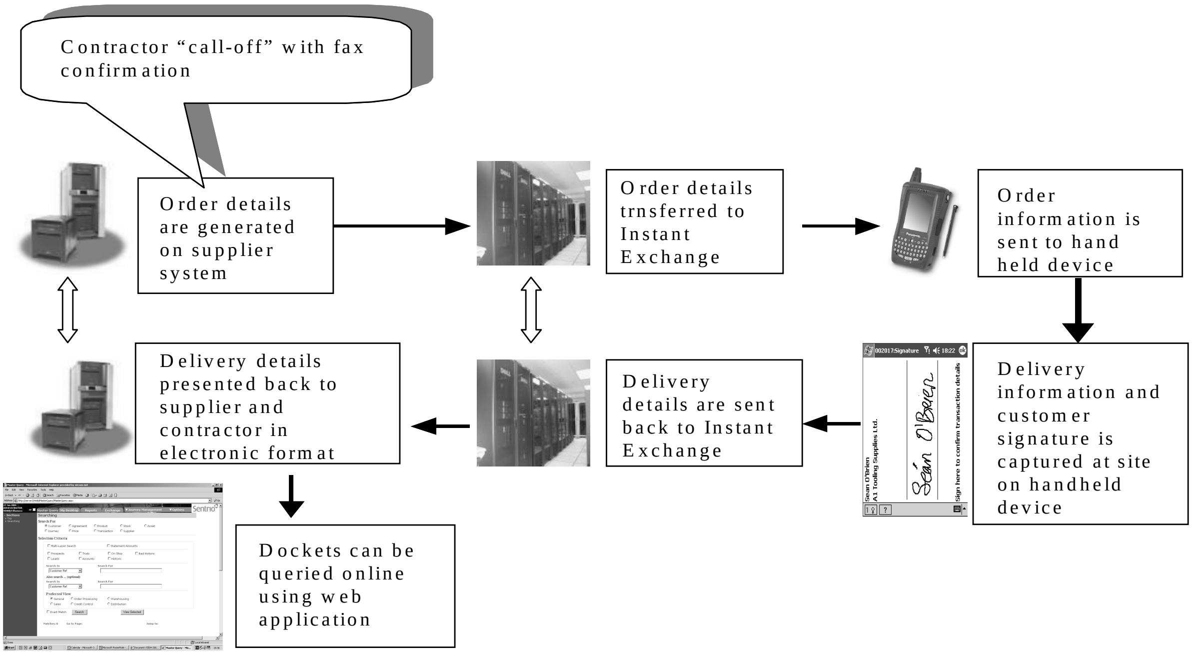

Figure 5. High Level Process for POD Pilot

4.7 Remaining Constraints

The pilot project allowed both the contractor and the supplier to report on the business benefits that would accrue if ICT was deployed in the ordering, receiving and invoicing processes of the purchasing cycle. Table 2 and 3 summarise the internal processes, constraints and opportunities for a further pilot project. It can be seen from both tables 2 and 3 that the pilot project only addressed the delivery element of the process. There remained a large number of constraints in both the contractor and supplier purchasing processes. For example, it was still necessary for the contractor to manually input a Good Received Note (GRN) of the POD information into their ERP systems. It is intended that all these constraints will be systematically dealt with in Phase 2 of the pilot, which is due to commence in spring 2005.

Table 2. Contractors constraints with existing process

4.7.1.1 Contractor – Processes and Current Constraints				
Process	**Current**	**Constraint**	**Pilot Objectives**	**Opportunities**
Ordering	Supplier "Open Order"	Keep order adjustments	Auto order adjustments based upon delivery information	SIG 1 – Phase 2
Receiving/ GRNs	Hard copy Delivery Dockets	Missing documents. Scanning documentation. Manual creation of GRN in ERP system.	Electronic proof of delivery. Eliminate scanning. Auto generation of GRN in to ERP system	SIG 1 – Phase 1 SIG 1 – Phase 2 SIG 1 – Phase 2
Invoicing	Cross referencing Invoice with scanned delivery dockets/GRNS	Missing GRN/scanning documents.	Auto generation GRN in to ERP system	SIG 1 – Phase 2

Table 3. Supplier constraints with existing process

4.7.1.2 Supplier – Processes and Current Constraints				
Process	**Current**	**Constraint**	**Pilot Objectives**	**Opportunities**
Demand from customer	Phone and facsimile	Need to put manually into system	Auto ordering into system from customer	SIG 1 – Phase 2
Delivery	Hard copy Delivery Dockets	Missing documents. Packaging of delivery dockets from site. Scanning of delivery dockets in accounts.	Electronic proof of delivery. Electronic proof of delivery. Eliminate scanning.	SIG 1 – Phase 1 SIG 1 – Phase 1 SIG 1 – Phase 2
Invoicing	Invoice issued once delivery initiated	Missing GRN/scanning documents.	Auto generation GRN in to ERP system	SIG 1 – Phase 2

4.8 Pilot Results

As a direct result of the pilot project, both the contractor and the supplier reported the savings that would potentially accrue should the technology be adopted in a second phase pilot to address the constraints identified in Tables 2 and 3. Tables 4 summarises these savings.

Table 4. Summary of Potential Savings for Phase 2 of Pilot

Contractors Annual Costs in Euro			Suppliers Annual Costs in Euro		
78,000 Invoices per annum 390,000 GRNs per annum			60,000 Invoices per annum 2,400 queries per annum		
Process	Ordering	20,000	Process	Demand from customer	20,000
	Receiving/GRNs	15,000		Delivery	100,000
	Invoicing	67,000		Invoicing	24,000
Total Savings Projected		102,000	Total Savings Projected		144,000
Add Work Study Factor +30%		31,000	Add Work Study Factor +30%		43,000
Other savings		5,000	Other savings		5,000
Total Savings Projected for Phase 2		138,000	Total Savings Projected for Phase 2		192,000
Less predicted technology costs		38,000	Less predicted technology costs		108,000
Nett Saving predicted for Phase 2		100,000	Nett Saving predicted for Phase 2		84,000

The savings reported in table 4 are based on calculations and data furnished by the contractor and the supplier during the pilot and not by a direct work study. The figures presented by the authors are considered to be conservative, as additional indirect savings in regard to office expenses such as use of paper, printing and copier consumables are not included.

From a pilot perspective the supplier gained the more immediate and tangible benefits, from the first phase of the pilot. Table 4 summarises the financial benefits that should accrue to both the contractor and the supplier should the technology be deployed in a second more dynamic B2B pilot project.

4.9 Pilot Feedback in Phase 1

Feedback has been seen as a critical part of the pilot study, as it not only provides "lessons learnt" but also substantiates the credibility of the technology deployed in the first phase of the pilot. There were teething problems in using the technology, however these problems bated as familiarity emerged during the pilot study. Both the contractor and the supplier felt that there needed to be more time spent on training personnel on using the technology. They also felt that the website was not user friendly and did not produce suitable reports for their records. There was also strong opinion that the Personal Digitised Assistant (PDA) screen was not displaying the requisite information prior to signing the PDA screen. All the feedback gathered from the participants will be consulted in the planning and implementation of the second phase pilot.

5. Proposed System Architecture for Effective ePurchasing

The first phase of this pilot project only dealt with the delivery aspect of the entire purchasing process. Figure 6 illustrates how existing technologies can be fully integrated to eliminate paper-work from the entire purchasing process. All purchasing documentation, such as requisitions, purchase orders, delivery dockets and invoices can be passed electronically through the central web server, which in turn can be electronically posted into both the contractors' and suppliers' ICT back-end systems. The architecture of the platform will enable a handheld application with an electronic signature capture capability to transmit wirelessly a POD from the PDA to both the suppliers and contractors ICT systems via an independent central web-based server. The web-based solution will provide on-line access to an image of the signed POD, which will allow for automated matching of the order, the delivery record and the supplier invoice.

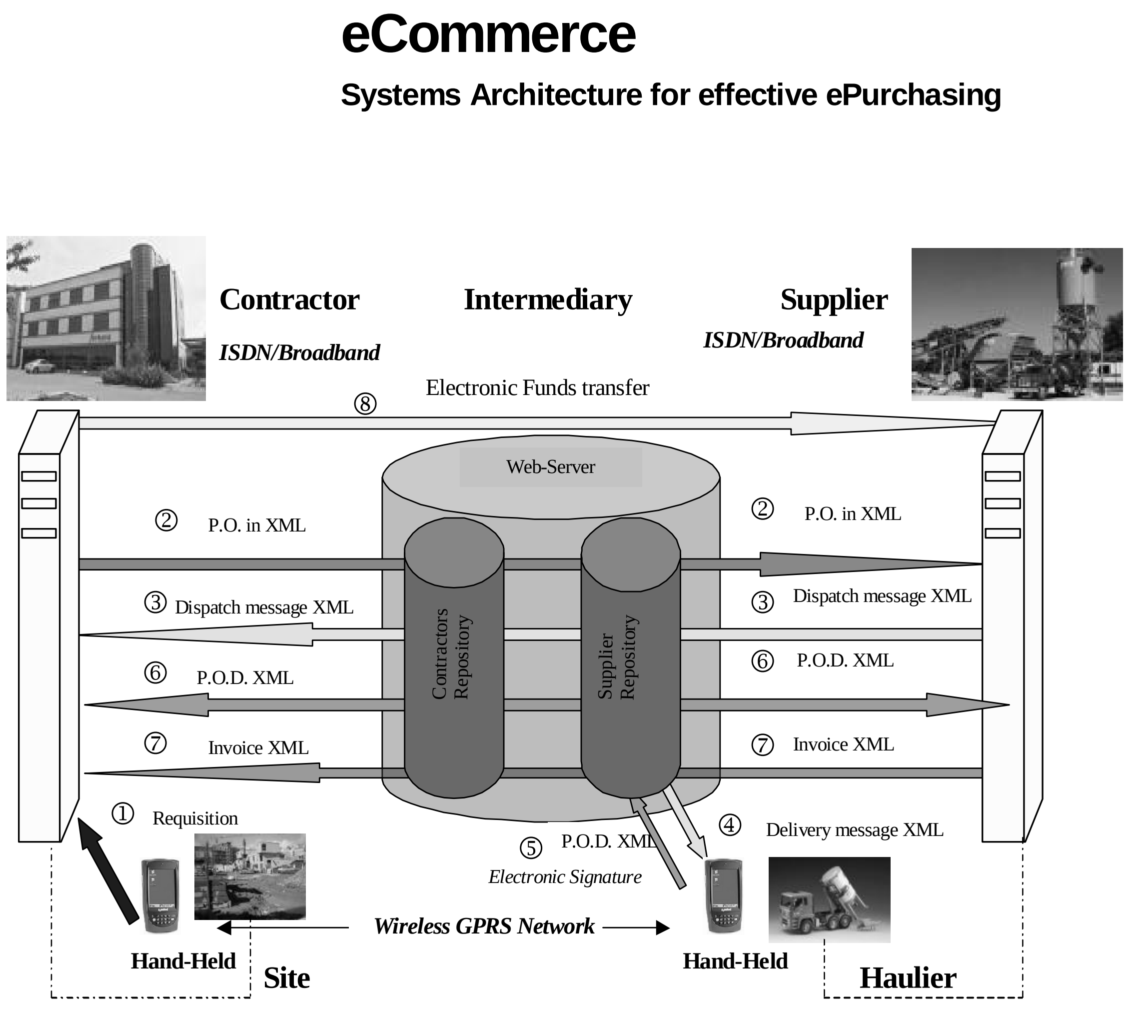

Figure 6. Systems Architecture for Effective ePurchasing

The operation of the proposed solution will involve the following sequential tasks, as identified in Figure 6.

1) Site requisition goods via a hand held device or mobile data terminal.

2) Contractor ICT system passes purchase order to the independent web-server, which ensures that the purchase format is correct and passes it to the suppliers ICT system.

3) The suppliers ICT system creates a dispatch notice and informs the contractor system if there is any variation between the order and dispatch notice.

4) The delivery details are sent to a delivery driver's hand-held device in XML format via a GPRS network. This message is triggered from the independent web-server based on the supplier dispatch message.

5) Once the delivery is complete the driver captures a signature on site, that is transmitted back to the independent web server.

6) The POD is then sent from the independent web-server to both the supplier's and contractor's ICT systems.

7) Supplier invoices the contractor via the independent web-server, using XML messaging technology.

8) On electronic invoice approval the contractor authorises electronic funds transfer direct to supplier.

6. Conclusions

Technologies are at last in place to process electronic transactions more easily and at less cost than one can process paper transactions [6]. ICT is changing almost all functional aspects of a modern business, particularly in industries such as financial services, travel and retailing. With the continued expansion of the Internet, EC provides unparalleled opportunities for businesses to bring greater efficiencies in transaction based commercial activities [7] and [11].

Specific EC deployment is having a varying impact on different business sectors. It will take the main players within each sector to adopt a new technological strategy. ICT is this driver that will force companies to embrace EC in B2B purchasing transactions. The technology behind EC is not the problem. The problem is getting the buy-in from all parties concerned. The biggest savings from eBusiness can be achieved from exchanging orders and invoices electronically. B2B savings can be realised on the elimination of duplicate data entry by achieving a three-way match of the purchase order, delivery advice note and the invoice. Increased awareness within the Irish construction industry is likely to be the key factor in encouraging wider uptake of EC technologies. An industry-wide education initiative, which combines the results of a pilot programme with dissemination of information within the technical press, could, in part achieve this goal. Such an initiative would most fruitfully comprise of a special interest group to pilot test the technology [12]. Particular efforts should be made to increase awareness of EC technologies among contractors and suppliers with lower levels of ICT utilisation [13] and [14].

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CDBKM- A Construction Draw-based Knowledge Map System

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Abstract

Knowledge Management (KM) has become an important term in the construction industry. Knowledge management involves creating, securing, capturing, coordinating, combining, retrieving and distributing knowledge. Most know-what, know-how and experience exists only in the minds of individual participants during the construction phase of construction projects. The knowledge can be reused and shared among the involved engineers and experts to improve the construction process and reduce the time and cost of solving problems. Sharing and reusing knowledge depends on acquiring and preserving both tacit knowledge and explicit knowledge as the property of a corporation. This study addresses application of knowledge management in the construction phase of construction projects and proposes a construction draw-based knowledge management (CDBKM) concept and system for engineers. This paper proposes a practical methodology to capture and represent construction project knowledge by using shop drawings. Using shop drawings as knowledge maps, users can get an overview of available and missing knowledge in core project areas and take appropriate management in tacit and explicit knowledge. Also, a web-based system is developed to assist and present project-related knowledge by providing keyword and map search on the Internet environment. The CDBKM system is then applied in a case study of a construction precast building project in Tainan to verify our proposed methodology and demonstrate the effectiveness of sharing knowledge special in the construction phase. By effectively using information and web technologies during the construction phase of a project, knowledge can be captured and managed to benefit future projects. The combined results demonstrate that, a CDBKM -like system can be an effective tool for all experts and engineers participating for construction projects by utilizing the knowledge management concept and web technology.

Keywords: Knowledge management; knowledge map; web-based application; information systems; construction project

1. Introduction

Thousands of construction drawings are produced for each construction projects. During the construction phase, engineers usually execute the project according to the shopping drawings. Therefore, the experience and knowledge concerned about the project will be resulted from those engineers. Recently, many organizations are now engaged in Knowledge Management (KM) efforts in order to leverage knowledge both within their organization and externally to their stakeholders and customers (Malhotra, 2000, 2001). Knowledge management in the construction phase mainly deals with the process of creating value from construction operation, organization to company knowledge. Valuable knowledge can be available in different forms and media, such as in the mind of experts, in operation procedures, and in documents, databases, intranets, etc.; however, knowledge management in the construction phase of projects aims at effectively and systematically collecting and sharing the experience and knowledge of the project by web-based and intranet technologies.The reuse of information and knowledge minimizes the need to refer explicitly to past projects; reduces the time and cost of solving problems, and improves the quality of solutions during the construction phase of a construction project. If experience and knowledge are shared, then the same problems in construction projects do not need to be repeatedly solved. Reduced problem-solving has the following advantages. (1) The cost of problem solving is reduced and (2) the probability of repeat problems is decreased. Several enabling activities should be considered to help to achieve the ultimate goal of efficient experience and knowledge reuse; experience and knowledge should be preserved and managed; that is, they should be captured, modeled, stored, retrieved, adapted, evaluated and maintained (Bergmann, 2002).

2. Problem Statement

Construction projects are characterized by their complexity, diversity and the non-standard nature of the production (Clough et al., 2000). Professional competency in project management is attained by combining knowledge acquired during training and skills developed through experience as well as the application of the acquired knowledge (Edum-Fotwe and McCaffer, 2000). Whatever successful and unsuccessful projects have been executed by the general contractors, a valuable record of each one should be kept to identify best and worst company practices. During the construction phase of projects, an effective means of improving construction management is to share experiences among engineers, which helps to prevent mistakes that have already been encountered in past projects. Drawing on experience avoids the need to solve problems from scratch: problems that have already been solved do not need to be solved again. According to a survey conducted for this study, most engineers and experts agree that KM is necessary and expect that knowledge management may benefit a construction project. However, no suitable platforms exist to assist senior engineers or experts in sharing and collecting their know-how and experiences when general contractors execute a project. This situation represents a major loss for general contractors who do not preserve the know-how and experiences of senior engineers and experts. When these engineers and experts complete projects or leave the company, they normally take domain knowledge with them and leave little or nothing that will benefit subsequent projects or the company. From the perspective of knowledge management, this know-how and these experiences of construction engineers and experts are the most valuable because their accumulation depends not only on manpower but also on the spending of much money and time.

3. Research Objectives

The main purpose for conducting this research is to develop a Draw-based Knowledge Management (CDBKM) system for engineers, to provide knowledge exchange and management service in the construction phase of a project for the reuse of domain knowledge and experience in future and other related projects. Usually, the management of knowledge in general contractor revolves around projects. Thus the capture, transfer, reuse, and maintain of the construction project knowledge are critical (Kamara et al., 2002). Knowledge management in the construction phase of a project is a knowledge-intensive organizational environment where knowledge creation has critical importance for general contractors. To be competitive, a general contractor has to make innovative use of knowledge created and accumulate through project activities, and share it across the rest of other relative projects. Engineers and experts participating in projects act as knowledge workers facilitating the collection and management of knowledge between current and past projects. In order to apply knowledge management to construction projects, the process and content of working construction knowledge need to be modified because of construction project characteristics. In order to improve the knowledge capture function, knowledge map assists the user as a tool to quickly note key concept, identify important processes and tools, and gain insights into associated behaviors.

4. Concepts of Draw-based Knowledge Management

A knowledge map is used to categorize the content within a particular discipline area. Knowledge map (Wexler, 2001) is a consciously designed communication medium using graphical presentation of text, models, numbers or symbols between makers and users. Knowledge mapping helps to understand the relationships between knowledge stores and dynamics. Davenport and Prusak (1998) note that developing a knowledge map involves locating important knowledge in the organization and then publishing some sort of list or picture that shows where to find it. The knowledge map plays important roles in implementing knowledge management. All captured knowledge can be summarized and abstracted through the knowledge map. The knowledge map also gives a useful blueprint for implementing a knowledge management system. The knowledge map in the system mainly deals with the assistance to find the needed knowledge easily and effectively. Furthermore, applying knowledge mapping technique has following two advantages. First, the knowledge map is represented in a simple, clear visual presentation in the knowledge management system. Second, the mapping methodology helps users to identify key most critical and available knowledge areas to the project. A knowledge map can be defined as a diagrammatic and graphic presentation of knowledge linking the relationships between knowledge and knowledge attribute.

Knowledge and information associated with units of shopping drawings in previous projects may be reused and applied in future projects. Information and domain knowledge from all projects are divided and saved as units for knowledge maps uses in categories related to the projects for collection and management. The main advantage of Draw-based knowledge management is easy for engineers to understand and find which past information and knowledge are available to refer and reuse.

When knowledge is captured duration the construction phase, the knowledge should be recorded in the platform for exchanging. In terms of explicit knowledge, project-related information or knowledge usually include specification/contract, reports, drawing, change order and data. Actually, each project does not contain one-to-one information or knowledge because some of them belong to draw-unit information. In contrast, tacit knowledge may include process records, problems-faced, problems-solved, expert suggestions, know-how, innovation, and experience notes. The information and knowledge is better to save by draw units as knowledge map because the result makes it easier to be classified and searched by users. In addition, users may search and refer to related information and knowledge from related activities in past projects. The tacit and explicit knowledge of Draw-based knowledge management is the same as the duration and relationship of Draw-based project management.

The relationship of current and past draw-units is important for users to link related information and knowledge together. Furthermore, not only the information and knowledge of the current project can be applied, but also same or similar draw-units of past projects can be referred to as experiences are recorded. When experts or engineers capture related information and knowledge regard to the project, they may edit information or knowledge into the drawings in the project. Of course, the system is designed to link among same or similar activities together based on high similarity automatically or manually. As shown in Figure 1, using draw-unit as knowledge map applies for knowledge management.

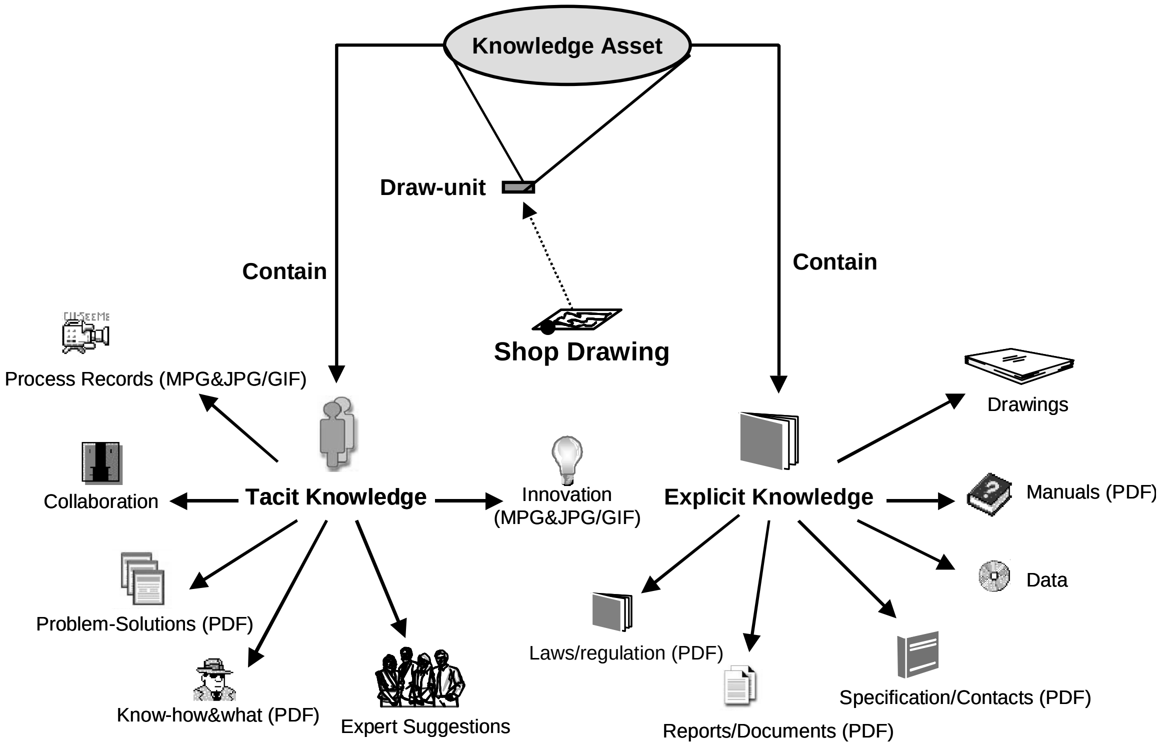

Figure 1. A concept map of the Draw-based knowledge management integrated with drawing units

4.1 Procedures for Utilizing the Knowledge Map

According to the construction knowledge management framework, procedures are proposed for applying the knowledge map in the CDBKM system. The procedure consists of the following three phases: knowledge determination phase, knowledge attribute phase, and knowledge linking phase.

4.1.1 Knowledge Determination Phase

The purpose of this phase is to provide a uniform, text-based intermediate representation of the knowledge types specific to construction projects. This phase includes defining knowledge and baseline taxonomy within a project. The scope of the knowledge map decides whether the knowledge map is constructed throughout a specific project. After deciding the scope, we determine the detail level of knowledge analysis. It is necessary and important to determine the proper level of detail to meet project-based knowledge demand effectively. When analyzing the source of knowledge within a project, activity is suggested as a unit to analyze the construction project knowledge. We analyze related knowledge based on draw-units of shop drawing. Tacit knowledge and explicit knowledge may exist in any project. After identifying knowledge through those activities of the project, we decide which knowledge needs to be extracted from the activities of the projects. Following suggested knowledge extraction techniques include interviewing with experts, making system analysis, and digital process record.

4.1.2 Knowledge Attribute Phase

A knowledge attribute illustrate the basic description of extracted knowledge and derive relationships with project and similarity draw-unit. The main purpose of knowledge attribute is provides the relationship and available knowledge information for knowledge workers and general users. Knowledge attributes include the keywords, description, project name, activity name, contributor, and attached files.

4.1.3 Knowledge Linking Phase

The knowledge link is identified after completing the knowledge attribute. The knowledge link is first indicated when the tacit or explicit knowledge is available and documenting, and is later confirmed. Two types of knowledge linking are proposed in the paper. One is draw-unit link draw-unit based on high similarity. Second is draw-unit link knowledge based on relationship between draw-unit and project. When the contributor creates a new link, the link needs to be examined and confirmed before knowledge map is published. Finally, all knowledge map need to be validated before the map is published. All the validation process must be communicated with domain experts, knowledge worker, and knowledge map producer in the enterprise knowledge management division.

5. The System

This section describes in detail the CDBKM system. The system architecture includes the Presentation Layer, the Business Logic Layer and the Data Access Layer (see Fig 2). After the user logging in, user is taken to the respective interface wherein information is classified under sections of ‘Project Info’, and the related entity. The architecture used is a three tiers model, with HTML, JavaScript /Servlets forming the user interface (presentation layer), the connection layer (JSP / JDBC) (Business Logic Layer) and the SQL RDBMS forming the Data Access Layer. The server of the CDBKM system supports three distinct layers - interface, access, application and database layers; each has its own responsibilities.

- *Presentation Layer:* Presentation Layer is responsible for the presentation of data, receiving user events and controlling the user interface. HTML/DHTML with JavaScript is used for developing User Interface Screens. Furthermore, Uses Socket class to communicate with server and Client side validations are done through JavaScript.

- *Business Logic Layer:* Business logic layer is created using ServerSocket class. It keeps listening for the clients to communicate with it for service. Every time a new client logs on, a separate session is created for processing its the following modules are developed in the Business Logic Layer.

- *Data Access Layer:* Data Access Layer tier is responsible for data storage. Relational database systems and MS SQL 2003 is adopted in the system. All the changes to the database occur after the exceptions are caught handled and confirmation for changes received. Also, system is developed to backup the system database automatically whenever required.

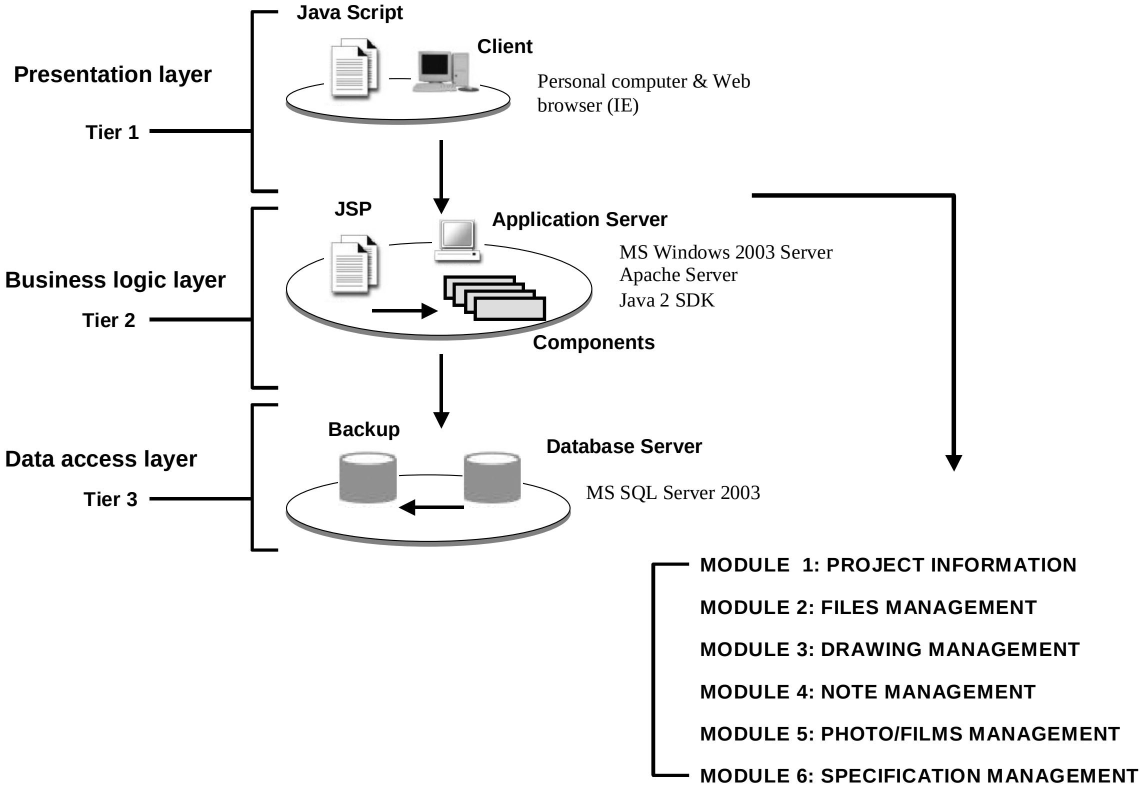

Figure 2. The system architecture and function modules

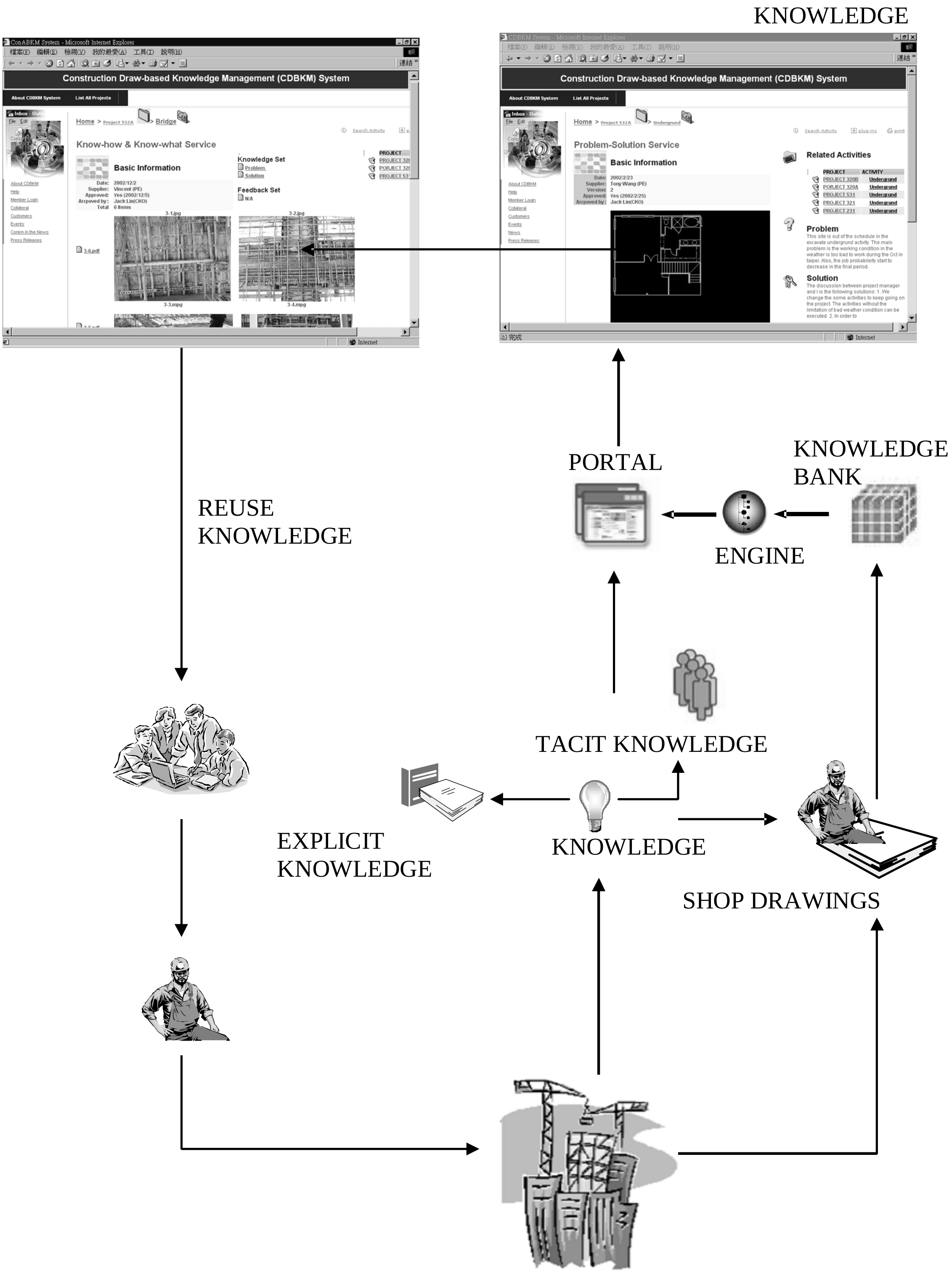

Figure 3. The application of knowledge sharing in CDBKM system

6. Case Study

In the following case, the general contractor won the bid of a precast project, to construct a High-tech office building within one year in Tainan. However, the contractor has no experience of precast construction and the contractor wants to record the whole valued experience and knowledge regard to the new project for further reuse. Therefore, the contractor decided to hire three construction specialists, particularly in precast construction to assist the senior engineers in order to finish the project on time as required. For the future precast projects could process more easily, the company decided to take a good advantage of knowledge management to pass on the valuable know-how to the engineers and manage it well to keep the knowledge inside the company. The following case study is the contractor applied and practiced knowledge management by using construction draw-based knowledge map system.

6.1 Knowledge Acquisition Phase

Knowledge workers help the senior engineer to collect related information/documentation and coverts it into digital format. After the related information and documentation have been digitized, the senior engineer edits descriptions/notes concerning that digital information and packages them as knowledge set into the related drawing-units.

6.2 Knowledge Extraction Phase

The senior engineer and knowledge workers record all the operating procedures by taking digital video and photographs. The senior engineer discussed problems with experts every week twice to accelerate the solving of the problem in question. All discussions were recorded and summarized as suggested by experts. Discussions and meeting with experts continued for ten months, until the problem was solved. The senior engineer recorded and summarized his experience and domain knowledge into the draw-units in the system to enable the problem's solution to be reused in other and future projects. The domain knowledge included the problem description (including documents, photographs, drawings and specifications), the problem's solution (including related documents and photographs and video of processes), and expert suggestions (such as notes, discussions and meeting records). Knowledge was extracted according to each process defined as related to the draw-units of shop drawings. Domain knowledge and experience was organized according to the attribute of the draw-units concerned. Furthermore, every senior engineer in the project is required to provide his own knowledge concerning the tasks for which he is responsible.

6.3 Knowledge Storage Phase

When the submitted knowledge set is approved, knowledge workers manage knowledge sets and classify this knowledge by placing it in an appropriate position (the draw-units of shop drawings) in the system. In other words, users can find and read related domain knowledge directly just clicking these draw-units of shop drawings. All knowledge map (draw-units of shop drawings) need to be validated to perform well before the map is published. All the validation must be conducted with domain experts, knowledge worker, and knowledge map producer in the enterprise knowledge implantation term. Finally, the knowledge set is automatically backed up from the knowledge bank to another database. After approving and storing knowledge, the system sends a message regarding the updating of the knowledge to the appropriate users automatically.

6.4 Knowledge Sharing Phase

The general contractor bid another precast project after the High-tech office building constructed six months ago. A senior engineer with no prior High-tech office building experience meets a similar problem and tries to locate past knowledge/information to help him solve the problem. The senior engineer uses the keyword search to find the expert who has domain knowledge concerned precast building. The senior engineer finds the experts and retrieves, refers to and studies the knowledge set (including digital video and documentation) supported by these senior engineers. He starts to apply and reuse the knowledge in his own project. Also, the senior engineer gives some feedback and offers knowledge that can be reused when others face new problems. Additionally, some senior engineers in other projects and reuse the same knowledge to solve the same problem at reduced cost.

6.5 Knowledge Update Phase

After applying knowledge and information to the other similar projects, the senior engineer solves his problem and finds a new solution in collaboration with other engineers. Finally, the senior engineer notes and submits the new suggestion and experience to project map, associated with the original knowledge. Furthermore, the knowledge is updated later because further feedback and another solution is provided regarding the same problem. After the approval process has been completed, the updated knowledge set is republished in the draw-units of shop drawings and notice message will be sent to the authorized members.

7. Conclusions

This study proposes the application of knowledge management in the construction phase of construction projects using a web-based technology and portal. The integration of knowledge management and web-based technologies appears to be a promising means of improving construction operation and management, especially in the construction phases of projects. The concept of Draw-based knowledge management (CDBKM) is presented, and a system for use as a knowledge-sharing platform in construction projects is presented. The construction Draw-based knowledge management system maps valuable information and knowledge into draw-units of shop drawings during the construction phase. The CDBKM system is advanced, at least in the following respects; the CDBKM system provides insight into the factors that have an impact on construction management, and so helps engineers to exchange knowledge and enhance the quality of the project. Participating engineers can interact with the computer to gain domain knowledge, and thus prepare for and participate in a construction project. Briefly, the CDBKM system can assist engineers by providing structured and unstructured information and knowledge by referring draw-units of shop drawings. The knowledge map in the system mainly deals with the assistance to find the needed knowledge easily and effectively. The primary purposes of using draw-units of shop drawings as knowledge map in the system are as follows; (1) the draw-units of shop drawings is represented in a clear and visual way to identify key knowledge areas that are most strategic and critical to the project, and (2) deals with the assistance for users to find the needed knowledge easily and effectively. The major contributions of the study are as follows; (1) proposing better solutions for construction knowledge management using draw-units of shop drawings, and (2) developing a construction knowledge management system specific for managing construction projects with reference to activities by using a knowledge map.

The demonstration of the system in a case study of the new precast office building located in Tainan indicates that the CDBKM system effectively promotes the sharing and reuse of knowledge for new construction projects. The case study also highlighted the need for improving knowledge management and exchange platforms. However, the received feedbacks based on the use of the system are as follows; (1) the content of knowledge bank in the system is not enough to support and provide the junior engineers to get past experience and knowledge in the beginning; (2) most of senior engineers and experts have low willing to share their knowledge and experience without the proper reword policy and strategy; (3) it takes time and is very inconvenient for senior engineers to edit and record the knowledge without any assistance form knowledge workers; (4) it takes time for knowledge workers to convert shop drawings into system, and (5) most senior engineers agree the CDBKM system is a useful platform for them to edit and manage their knowledge and experience.

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How to Describe and Evaluate Management System with the Unified Modeling Language

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Abstract

This paper reports how to use the Unified Modeling Language (UML) as a methodology of the development of computer systems, especially for project management in building construction. First, the paper introduces the features of construction project. The authors value the end user computing (EUC) from the viewpoint of organization, and Design Pattern of user interface from that of viewpoint of computer system structure. Secondly, the paper explains the role of UML, and design patterns of user interface with UML. Thirdly, the paper describes the process of actual system developments with UML: Mobile Computer-Aided Management System, Schedule Simulator for Repetitive Construction Work, Long Term Repair Planning System, and Life Cycle Cost Estimation System. Moreover, it develops the evaluation of system with UML. Finally, the paper summarizes the methodology and discusses the effectiveness.

Keywords: Project management, building construction, computer-aided engineering, end user computing, modelling, unified modeling language

1. Introduction

1.1 Building Construction and Project Management

Building Construction has some features as follows. It is unique and local production. The design and specification is unique. Production is usually executed as a project. So, members in a project such as an architect, a general contractor and subcontractors are usually organized each project. On the other hand, project management for construction has unchangeable and important core. For instance, quality, cost, deliver, safety and environmental control are essential these days. Many check points for them have already arranged. However, at the same time, project managers must cope with the diversity of projects. The strategy in project will change priorities in project management. The structure and specification of building may affect the process and the point in project management. The adoption of construction methods such as precast concrete will change the work flow of management. That of construction methods such as the division of work area will change the frequency and time of management work. So, project management for construction needs the variability corresponding to the project[5, 7].

1.2 Rapid Expansion of Information Technology

Information technology has rapidly expanded in construction project. Construction managers have recently handled various types of digital information such as drawings, specification, checklists and daily reports. They use computers for construction planning and management. They also use networks: the internet, the intranet, and LAN for the communication among project stakeholders and their data exchange. On the other hand, they need to access the real construction site to manage the construction project. Now the current mobile computing can improve the management work in construction site, and enhance the total productivity of construction management. They have recently used mobile computers for the site management [3, 7, 8]. Information technology is essential in the current construction project. At the same time, it must have the variability corresponding to the feature of construction project.

2. Application of IT in Project Management

In the application of information technology in project management, the authors have practiced the application of EUC and design pattern. The former is the approach from the viewpoint of organization, and the latter is that from the viewpoint of computer system structure. Both are the mechanism to get the variability in computer systems.

2.1 End User Computing

The authors recognize that EUC is a useful concept corresponding to enhance the customer satisfaction. Strictly speaking, EUC means that end users develop computer system to support their own work. However, it is still unrealistic that end users, architects and/or construction managers, develop the whole of the computer system for their work. In general, their current literacy for the development of the system is not enough. So, the authors have promoted that end users, architects and/or construction managers, take part in the development of computer system supporting to project management for construction. The EUC means that the collaboration of end users and system developers. The EUC makes it easy to consider the opinion of end users. However, there is another opinion that EUC derives many poor imitations from the original easily. As a result, the use of computer in the organization gets confused. So, a useful mechanism about the structure of computer system is necessary.

2.2 Modularity and Design Pattern

The authors adopt Modularity and Design pattern as key concepts to realize the EUC. Figure 1 shows their overview. A module is a part that performs a particular function. A system component is an embodiment of module in computer system. The feature is the encapsulation of the internal mechanism, and the interface between the internal and the external. The interface means the connection between components. The components realize Object-Oriented Design.

The practice of Object-Oriented Design produces design pattern. Design pattern is repeated and regular forms in the diverse combination of system components. For instance, there is a scrollbar. This is a system component about user interface for the change of objects such as data and/or screen. If the object is the second dimension, the user interface with two scrollbars is adopted. If it is the third dimension, the user interface with three scrollbars is adopted. Either of them is mostly used in real works. They are design patterns. The rule about design pattern, including how to combine system components and how to combine design patterns, is design rule. The authors regard design pattern of user interface as important. End users can take part in the design of user interface because it is directly related to them. That is, they can customize and combine the design patterns of user interface freely under the design rule. After the completion of the preliminary design with design patterns by end users, system developers can complete the computer system easily. They can develop the computer system corresponding to unique features of project quickly. This is the mechanism of diverse and rapid design [2, 4, 8].

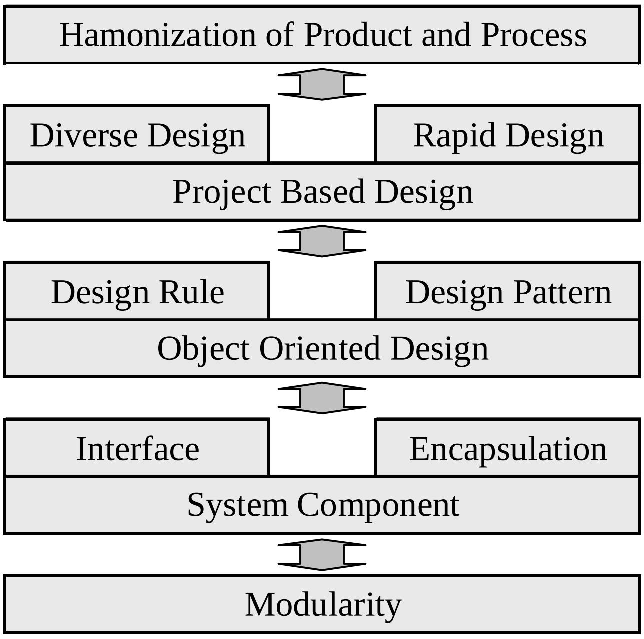

Figure 1: Concept of Modularity and Design Pattern for Product and Process

2.3 Problems to be Solved

The authors have developed actual computer systems based on EUC and design pattern: Mobile Computer-Aided Management System, Schedule Simulator for Repetitive Construction Work, Long Term Repair Planning System, and Life Cycle Cost Estimation System. Through these developments, the authors understand that the modelling, which both end users and system developers can understand, is necessary and important. There are two points in the modelling. One is the expression of system mechanism such as design pattern and system component. It is necessary for end users to recognize the function, control, and behaviour of computer system. It is also important for system developers to be able to build a computer system with the model. In other words, the modelling must be a design tool from the view point of end users, and be the blueprint from that of system developers. Design pattern can satisfy both requirements. The other is the function of a communication tool between end users and system developers. Common language between them is necessary. A useful language not only between end users and system developers but also among system developers is important.

3. UML as Methodology of Description and Evaluation of Management System

UML is a graphical language for visualizing, specifying, constructing, and documenting the artefacts of a software-intensive system. UML offers a standard way to write a system's blueprints, including conceptual things such as business processes and system functions as well as concrete things such as programming language statements, database schemas, and reusable software components [10]. UML defines some diagrams to describe complex systems. There is some possibility of using UML as a useful design and communication tool.

The authors arranged UML diagrams and set up the modelling flow for this research. Figure 2 shows the flow and the role of each diagram. Users in this modelling are end users and system developers. Diagrams are classified in three broad categories. They are basically used in ascending order, but sometimes in parallel.

- The first category is the description of use case. Step 1 is the description of use case. Users arrange actual use cases and define the relationship among them with Use Case Diagram. Users describe a scenario each use case. The scope and use of system becomes definite.
- The second category is the description of model behaviour. It is the description of dynamic structure of system. Step 2 is the description of model process. Users describe the work flow of the model with Activity Diagram. This helps the definition of scope of computer system. Step 3 is the description of message flow. Users describe the message flow in the model with Sequence Diagram. This helps the definition of data flow in system. Step 4 is the description of the flow of user interface model. Users describe the flow with Sequence Diagram. As mentioned above, user interface is an important component in EUC. Authors arrange the model with UML diagram. Step 5 is the description of state transition. Users describe the state transition of the system condition with Statechart Diagram. This is especially useful for the description of the repetitive procedure.
- The last category is the description for the implementation of system. Step 6 is the description of class structure. Users describe class structure with Class Diagram. Class is an abstract concept and is refined through the description of case studies and model behaviour. Step 7 is the description of system structure. Users describe the dependencies among software and the structure of hardware with Component and/or Deployment Diagram.

Case Study	1	Use Case Diagram	Description of Use Case
Model Behavior	2	Activity Diagram	Description of Model Process
	3	Sequence Diagram	Description of Message Flow
	4	Sequence Diagram	Description of GUI Flow
	5	Statechart Diagram	Description of State Transition
System Structure	6	Class Diagram	Description of Class Structure
	7	Component Diagram Deployment Diagram	Description of Ssytem Structure

Figure 2: Flow in the Use of UML

4. How to Describe Management Systems with UML

Examples of the description of systems with UML from the viewpoint of both the definition of system and the communication between end users and system developers are as follows.

4.1 CASE 1: Mobile Computer-Aided Management System

The inspection system with the personal digital assistants (PDA), especially for finish work of dwelling apartment, is a subsystem of Mobile Computer-Aided Management System [7, 8].

The first step of modelling in this research is the description of the use case. Figure 1 shows Use Case Diagram of the system. It shows that an inspector is an actor of using the system, and that a rectifier is one of receiving the benefit of the system. Clients, supervisors, construction managers and foremen can be the user of the system. Foremen are the rectifier of defects. Moreover, the diagram shows that the system includes five sub works such as “record the position” and “issue site instruction”. These sub works show a scenario in the case that an inspector inspects dwelling units. In a scenario, a construction manager in general contractor uses the system, and issues site instruction to foremen. The work of “record defects in dwelling units” extends to the overview of the system. The inspection for common corridor is possible as another use case.

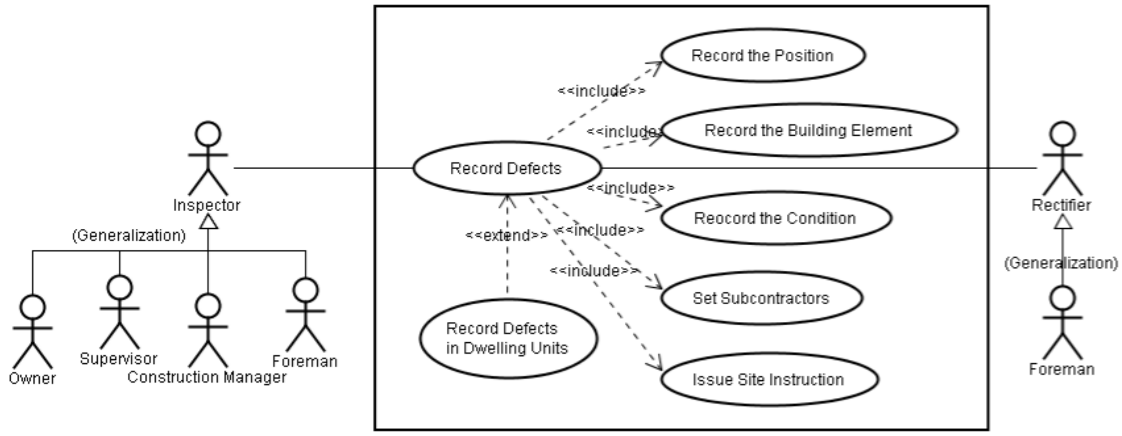

Figure 3: Use Case Diagram of Mobile Computer Management System

The second category is the description of system from the dynamic view point. The data exchange in the system and the state transition of the system are described as the behaviour of system. Activity Diagram basically indicates a flowchart. It makes clear of the flow and sequence of sub works. It usually sets the lane for the persons concerned. The lane makes clear each role in the inspection. Moreover, works in the diagram can be classified by the type of content such as decision making and data input. This classification is related to the scope and role of computer system. Figure 4 shows Sequence Diagram. It focuses on the message flow. The related subjects are the sender and receiver on messages. They are the actors such as an inspector and the parts of the system. This diagram is also related to the scope and role of computer system.

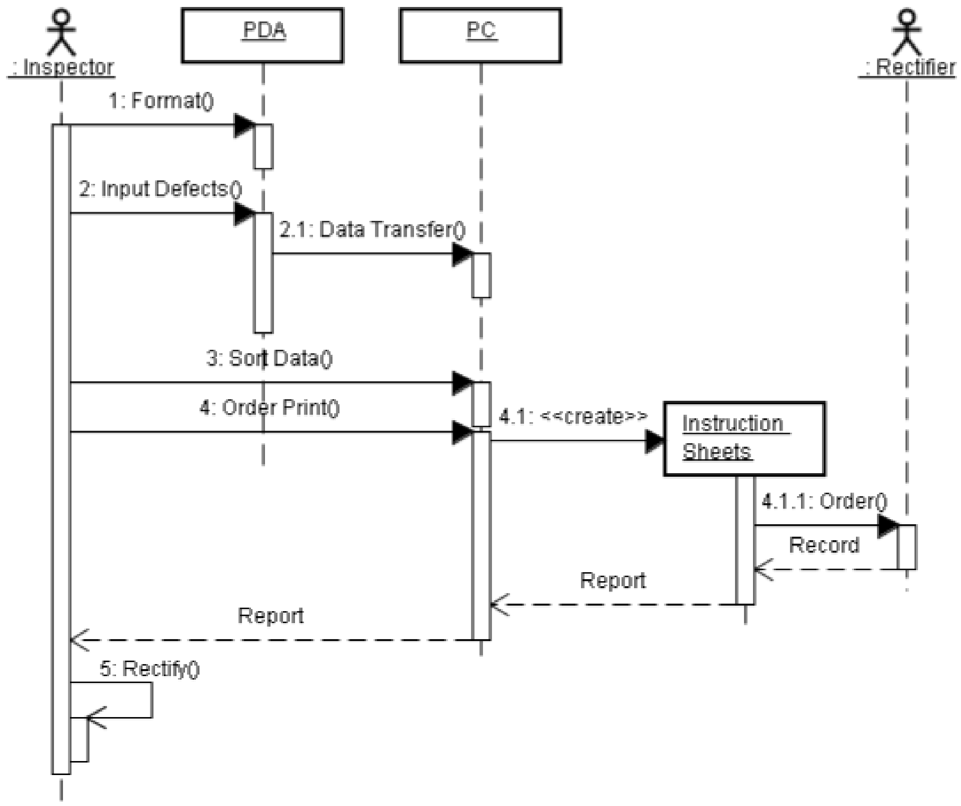

Figure 4: Sequence Diagram

The authors recognize the graphical user interface (GUI) as the important object of design pattern for EUC. It is familiar to both end users and system developers. The left sequence diagram in Figure 5 shows the message flow around GUI model in the inspection system. This model, which the authors have arranged for EUC, has five properties. The first one is the name of design pattern such as pattern-A and pattern-B, which is just for the identification. The second one is the type of control of system component such as the list and the scrollbar. In this case, this means a tool in data input. The third one is the type of access to GUI such as the selection of item and the direct input of information. The forth one is the type of data such as Integer, String and Boolean. The fifth one is the number of system component. The type of data is related to the control and access. For instance, the selection of an item from the list is suitable for the input of an item. The use of scrollbar is suitable for the input of numerical data, especially by construction managers with gloves out of doors in construction site. As Sequence Diagram shows the message flow, the input and output in the system becomes clear. The content of this GUI model is also familiar to both end users and system developers. Therefore, this flow can be designed by the collaboration of end users and system developers. Once GUI models are established, the development of actual GUI is easy and doesn't need much time because the model, design pattern, has designed the detail of the specification in advance. The right one in Figure 5 shows the development of actual GUI in the system.

The third category is the description of system structure from the static view point. Figure 6 shows Class Diagram of the inspection system. Class Diagram is a graph of classifier elements connected by their various static relationships [10]. The diagram shows the structure of elements and the relation among the elements in the system. The information of the inspection for buildings is composed of inspection information, building information, drawing information and defect information. The information has the properties. The diagram also shows the relation between the actors and the system. The description of overview of organization including the actors and the system will be able to become a tool for the description of business model. Figure 7 shows Deployment Diagram of the inspection system. First, it expresses the component of hardware. Processors are PDA and PC. Secondly, it also expresses the structure of the software including the relation the software and the operating system.

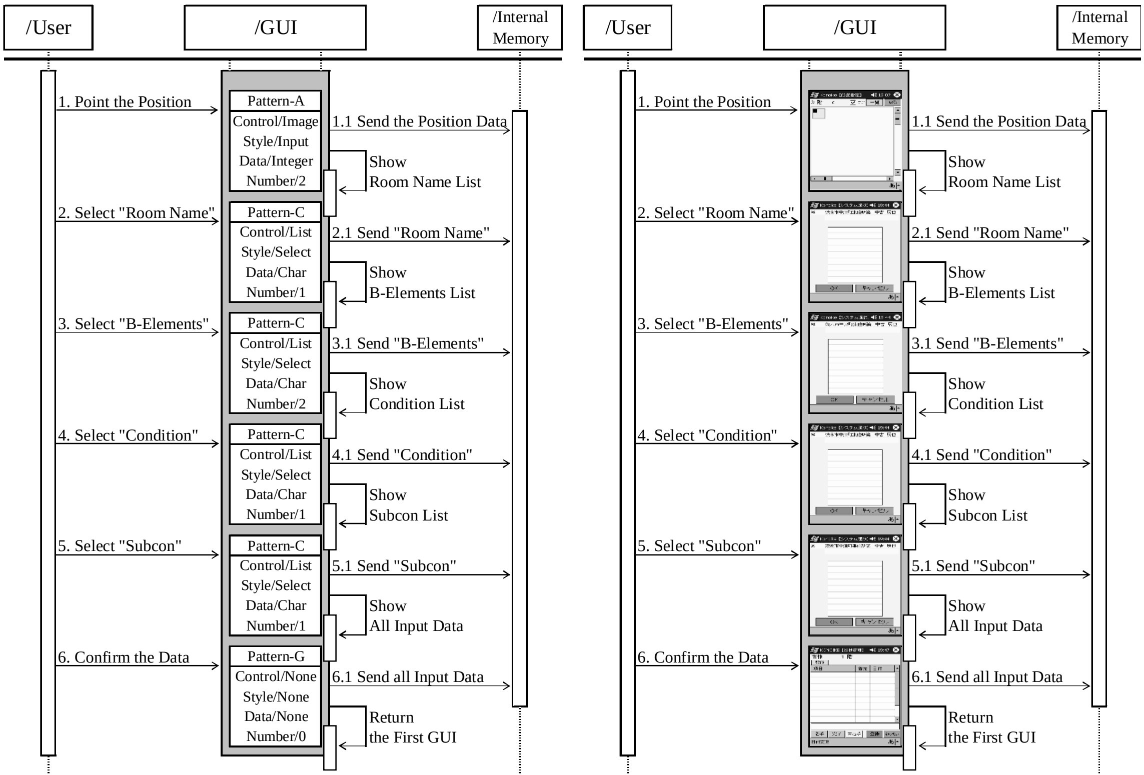

Figure 5: From User Interface Model to Real Graphical User Interface

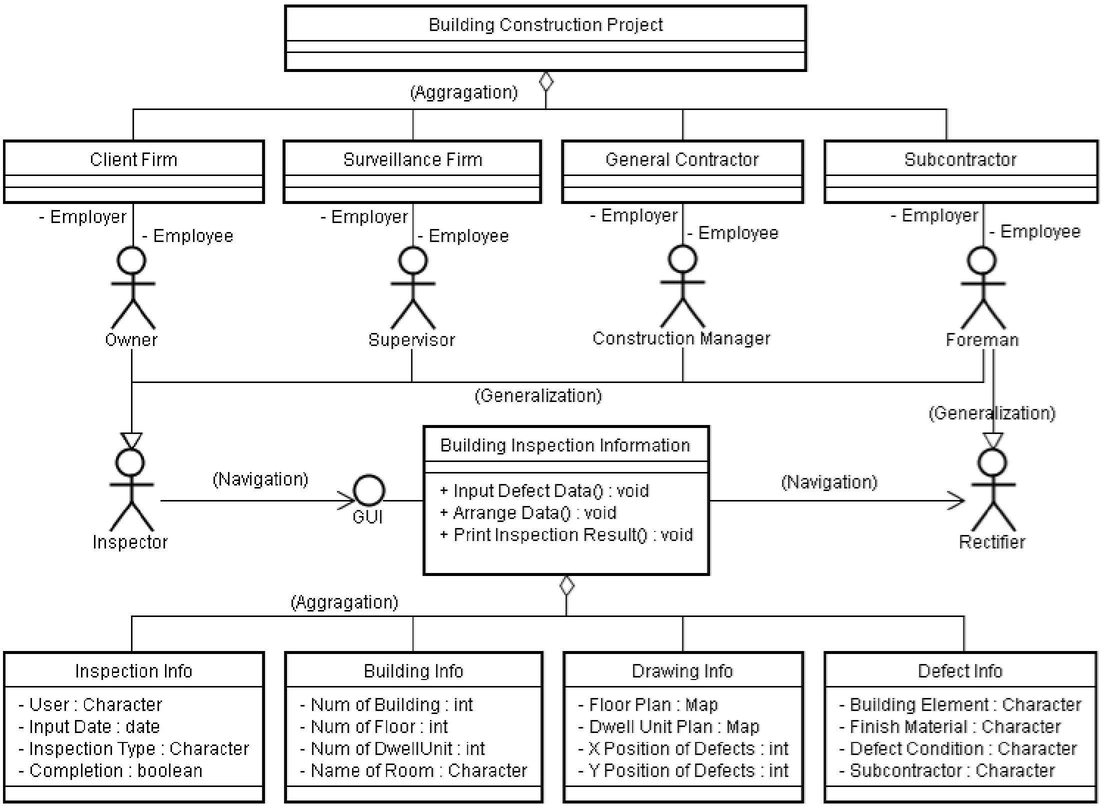

Figure 6: Class Diagram of Mobile Computer-Aided Management System

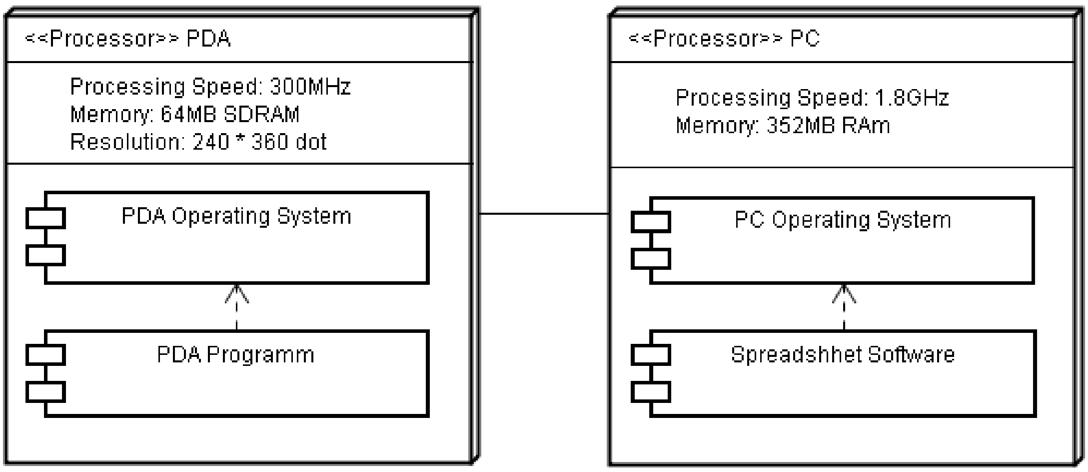

Figure 7: Deployment Diagram of Mobile Computer-Aided Management System

4.2 CASE 2: Schedule Simulator for Repetitive Construction Work

Figure 8 shows Use Case Diagram of Schedule Simulator [5]. The meaning is as follows. The system is an interactive one. Construction managers use the system for their own construction planning. They set up the system and get the answer. The planning of cycle schedule with the simulator is composed of three sub works: “set a construction plan”, “get the schedule” and “evaluate the schedule plan”.

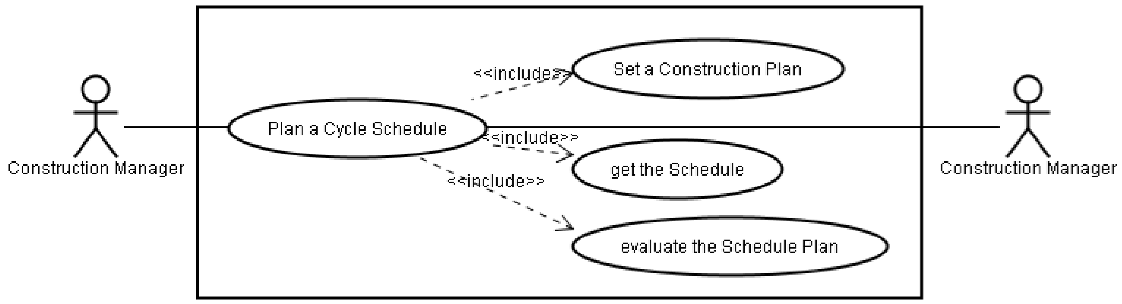

Figure 8: Use Case Diagram of Schedule Simulator

Figure 9 shows Class Diagram of the system. The meaning is as follows. Class in the system is divided to two categories: the planning and analysis, and the scheduling. The former has three classes: Plan, Database and Plan Analysis, and the latter has three classes: Relationship, Schedule and Graph. Figure 10 shows Deployment Diagram of the system. Spreadsheet software takes charge of the category of planning and analysis. Scheduling software takes charge of that of scheduling. The graphical user interface is directly connected with the spreadsheet software. End users use the function of the scheduling software by way of the spreadsheet software.

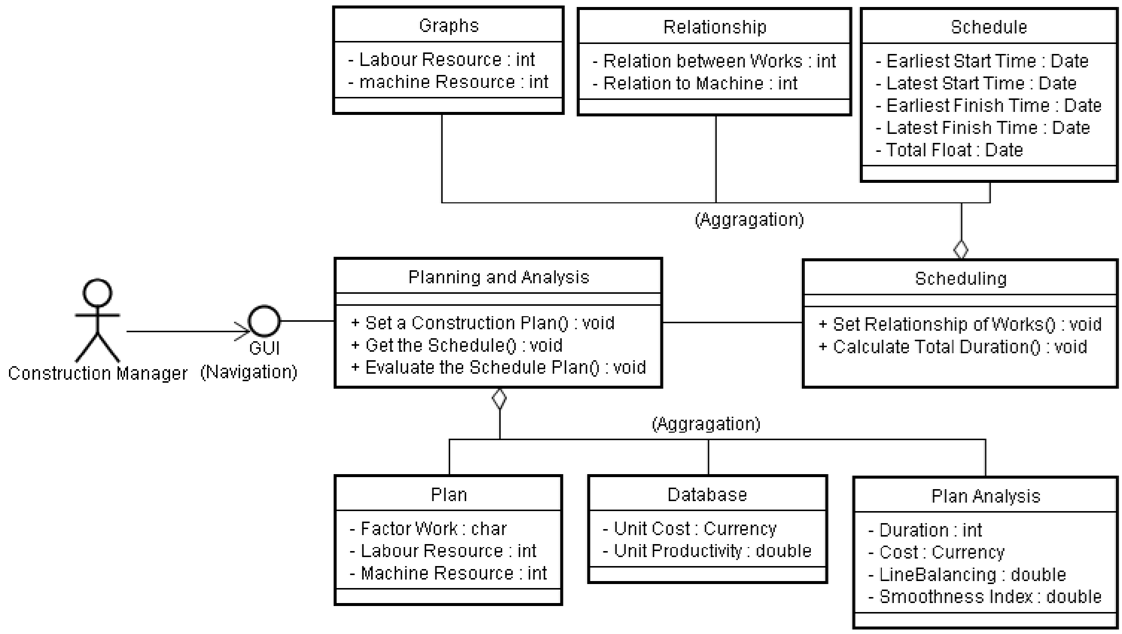

Figure9: Class Diagram of Schedule Simulator

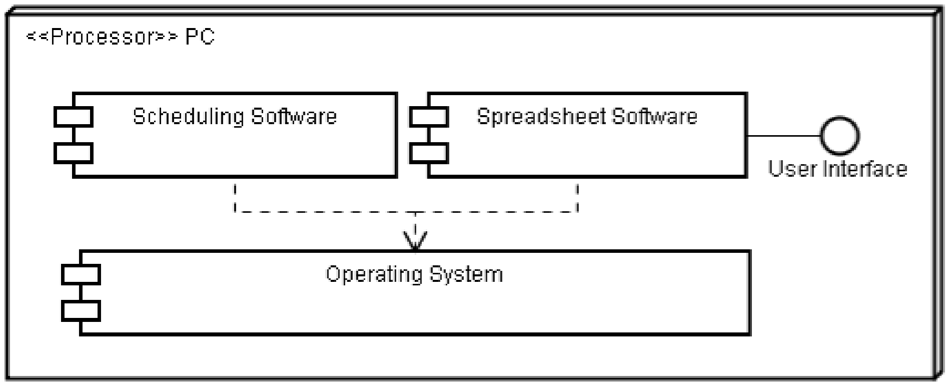

Figure 10: Deployment Diagram

4.3 CASE 3: Long Term Repair Planning and LCC Estimation System

Figure 11 shows Use Case Diagram of Long Term Repair Planning (LTRP) System [6]. It shows that construction managers and equipment engineers use the system, and that the owner and facility managers get the result. The system is composed of making a long term repair time table, and calculating the annual expense.

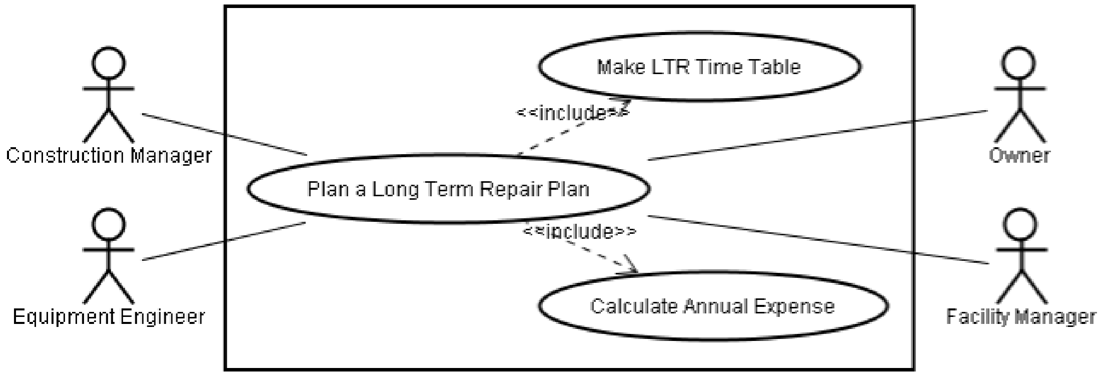

Figure 11: Use Case Diagram of Long Term Repair Planning

Class Diagram in figure 12 shows the structure of the systems: LTRP System and LCC Estimation System. These systems hold the data of cost and repair cycle for buildings in common. The diagram also shows the users. Sequence Diagram in figure 13 shows the message flow between users and LCC Estimation System, and that between the system and the database.

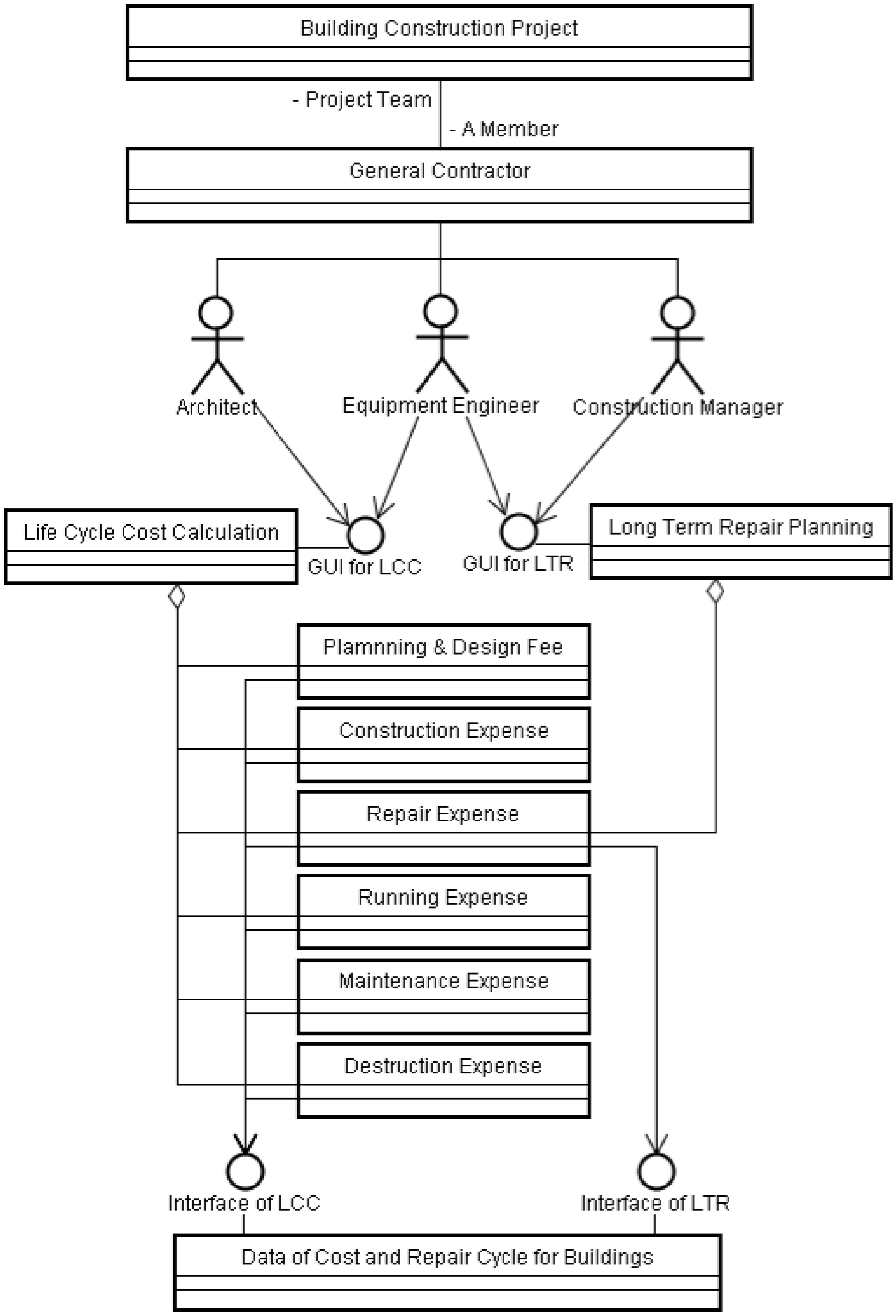

Figure 12: Class Diagram of LTR&LCC System

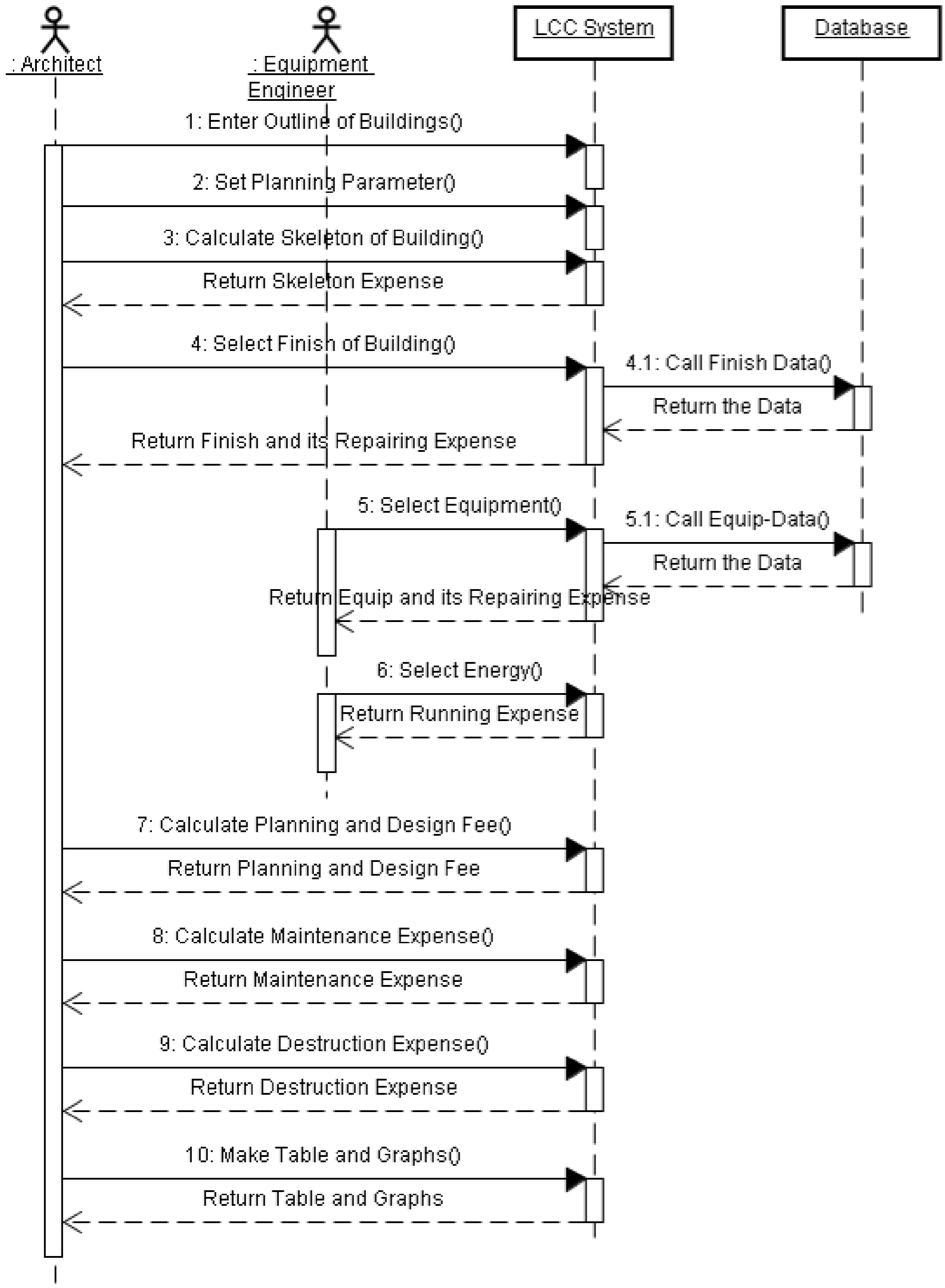

Figure13: Sequence Diagram for LCC

5. How to Evaluate Management System with UML

The introduction of IT systems usually aims the improvement of productivity and/or the extension of the function in the system. Therefore, end users and system developers must estimate the change, examine the effect, and evaluate the new system carefully. The tool for them is necessary. There is some possibility in the description of the system with UML.

5.1 Analysis of Shorter Working Hours and Working Saving

UML is a graphical language for visualizing, specifying, constructing, and documenting the artefacts of a software-intensive system [10]. Therefore, it can express the difference between systems visually. Figure 14 shows sequence diagrams of two models about the inspection work. Model 1 is the traditional way with paper sheets for both the data input and the rectifying order. Model 2 applies Mobile Computer-Aided Management System for inputting the data and making the order sorted by subcontractor. The comparison shows that the working hours and volume of inspectors decreases at the transition from Model 1 to Model 2. Moreover, Model 2 holds the data and creates the inspection sheet as a digital form. This means the door open to the further development. For instance, the analysis of the defect data is possible. All stakeholders will be able to hold the result in common through the network.

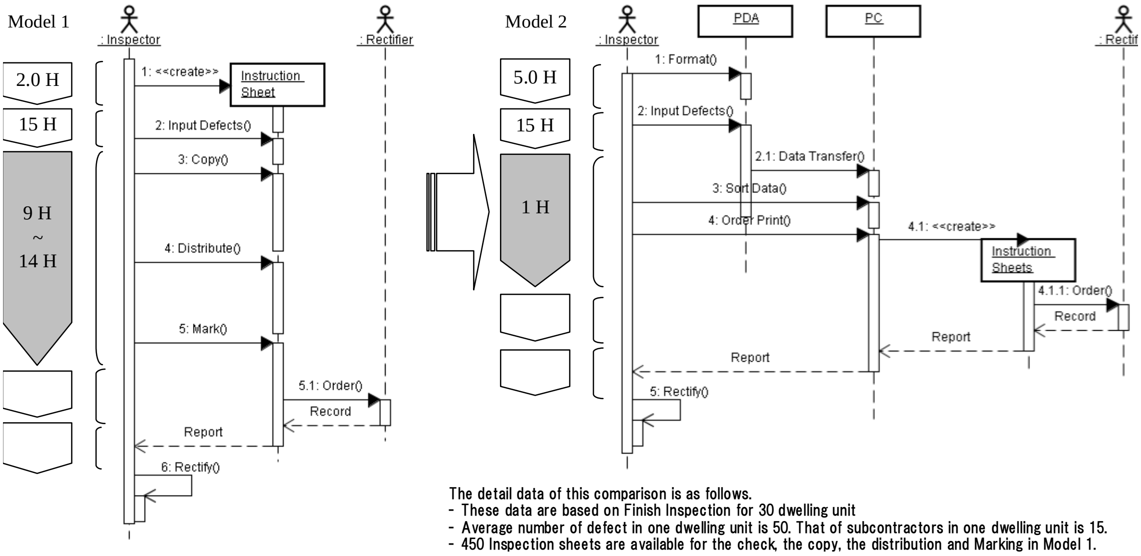

Figure 14: Comparison of models with Sequence Diagram

5.2 From Project-based Analysis to Company-based Analysis

Not only project-based analysis but also company-based analysis is necessary in the improvement of work because the work out of project such as the development of the system and the maintenance of database exists. The consideration of added value of systematisation with IT is important. So, the description of business model has been more important [1, 9]. The enlargement of the description scope will improve the precision of the evaluation.

6. Conclusions and Discussion

This paper describes the methodology of the description and evaluation of management system with UML. Especially, the authors aim the information system based on EUC and design pattern at a target. EUC is the approach from the viewpoint of organization, and design pattern is that from the viewpoint of computer system structure. Both are the mechanism to realize the diverse and rapid design of information system.

First, the paper shows the function of diagrams and the order of their use. The paper demonstrates the description of three systems with UML. Use Case diagram can show the use case of the systems. Sequence diagram can show the data flow in the system. Class diagram can show the organization of actors and information in the system. Deployment diagram can show the composition of hardware and software in the system. The paper shows the description of the actual systems and confirms the function of UML as a useful tool to describe the diverse of computer system.

Secondly, the paper proposes the user interface model in sequence diagram. The model is the key in the communication between end users and system developers because end users can give their opinion to the user interface. Moreover, the authors propose design pattern for the model. It makes it easy for end users to approach the model. Once the model is established through their discussion, system developers can develop the system easily and rapidly because design pattern has designed the detail of the specification in advance. In Mobile Computer-Aided Management System, the authors have actually derived some subsystems with design patterns: the inspection system, the progress monitoring system, the position check system, and the checklist and reference system. The paper indicates that EUC and design pattern are useful for the project-based development of computer system corresponding to project management for construction, and gives demonstrations.

Finally, the paper shows the comparison of two sequence diagrams as the evaluation of the system with UML. The one shows the traditional way with paper sheet for the inspection work. The other shows the application of Mobile Computer-Aided Management System. The comparison indicates the difference of data flow clearly. However, sequence diagram doesn't show the work volume. The authors add the information of necessary time for factor process. As a result, the diagram makes clear of the shorter working time by the introduction of the computer system. The evaluation of computer system needs the company-based analysis. More extension of UML is necessary. Marshall, Erickson and Penker have extended the function of UML for the description of business model [1, 9]. On the other hand, UML has spread as a tool for the description of computer system in actual business. The authors have tried to extend UML from the viewpoint of the evaluation of computer system in business. The authors expect that this result compensate the gap between at the tool level and at the business level.

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ICT in Construction and Facilities Management

ICT today is maturing fast and is seen as a key enabler for the better planning, monitoring and control of construction and facilities management activities. It has gone beyond the simple functional purpose of scheduling projects or estimating costs. In fact integrated ICT systems are being used to manage the complete building lifecycle. The use of product models in the form of complete building information models are but one step in this direction.

This book provides a portfolio of ideas and perspectives into the use of ICT for construction and facilities management. How can it be used for design management, management of facilities, and management of construction projects and processes through a shared product model, for managing knowledge, etc. are some of the aspects that are covered. The key question is whether ICT will transform construction and facilities management, or will it serve as a catalyst and enabler for this change.

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Abdul Samad (Sami) Kazi

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Preface

The construction industry is a project-based one with the delivered product changing from project to project under the influence of many different factors, one of them being context. This context could as an example be simply the physical conditions surrounding the landscape where the product (the building) is to be delivered. Consequently each day on the construction site brings forth a new problem and a new solution. These problems and solutions are rarely well documented and valuable lessons learned confined to the minds of only those who experienced them. There is little, if at all any follow-up or analysis that may yield valuable lessons learned or new ways of managing projects more effectively and efficiently. Is this due to the way projects are managed in construction, or does the root cause of this lie elsewhere? Based on our experience, do we need a fresh new look at how construction projects are planned, monitored, and controlled?

In Evolution of Physics, Einstein and Infeld [1] state:

> "*Creating a new theory is not like destroying an old barn and erecting a skyscraper in its place. It is rather like climbing a mountain, gaining new and wider views, discovering unexpected connections between our starting points and its rich environment. But the point from which we started out still exists and can be seen, although it appears smaller and forms a tiny part of our broad view gained by the mastery of the obstacles on our adventurous way up*."

Through considerable reflection on the way projects are managed in the construction industry, there has been a move towards an analysis of the underlying theory of project management and its applicability to construction projects. Different viewpoints/perspectives have been presented [2, 3, 4, and 5] and surely more are to follow. Section I of this book is a brief insight into some recent developments.

In the coming years, the construction industry will lose a large portion of its skilled force [6]. It is not only the loss of this skilled force that is a matter of concern for construction organisations, but also the experiences and knowledge that this skilled force will take with them. According to Albert Einstein, "*The only source of knowledge is experience*"[1]. This has been one of the earlier guiding principles of the construction industry where, skills were passed on from master to student, from one generation to the next; the construction industry of yester years was a pool of skilled craftsmen. Industrialisation, large scale projects, and a large mind shift to profitability over the years have changed the very nature of the way industry operates today. In the past, focus was on the transfer of skills to maintain a set of skilled craftsmen, whereas today the focus is on shortening construction times, minimising costs, and effectively utilising resources. Organisations

[1] http://uk.encarta.msn.com/text_761562147___4/Einstein_Albert.html

today are waking up to the reality that their most valuable asset is the intellectual capital (knowledge and experience) of their employees. Significant efforts are being put in place to try to manage this knowledge through social interaction, and to transform organisations into *learning* organisations.

This book is a collection of how learning from experience has contributed to the identification of new challenges, development of new theories, and management of knowledge in construction. Case studies provide practical insights into the subject matter.

How has project management evolved, what have we learnt, what are future research frontiers, should we be managing projects as if we were managing production, can public institutions stimulate innovation in construction, how do social networks contribute to organisational learning and knowledge sharing, etc., are some of the questions this book provides answers to.

Acknowledgements

This book would not have been possible had it not been for the untiring efforts of Dr. Kalle Kähkönen, Chief Research Scientist, VTT – Technical Research Centre of Finland, in championing the scholarly book series on *Combining Forces – Advancing Facilities Management and Construction through Innovation*. A special note of appreciation is extended to all contributing authors for their willingness and enthusiasm in sharing their research and experiences from practice.

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May 2005

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Section I

Evolution of Project Management – New Perspectives and Research Frontiers

Project Management in Chaos

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Abstract

Traditionally, project management (PM) has been seen as a stable and non-dynamic, linear process. By using traditional risk analysis, one will find only the most probable risks. In reality, the big risks that have never occurred before will remain unidentified. The traditional tools in projects are the Work Breakdown System (WBS) and network planning (PERT). A careful breakdown of a process is of no use if activities are unknown. The network approach does not approve of feedback loops. In addition, the correlations between the durations of activities are forgotten in both the planning and the risk analyses. The PERT or the risk analysis works if external disturbances, feedback loops, and internal correlations are ignored. However, they are not applicable in a state of chaos, on the edge of chaos, or in chaotic environments. Herein, the general chaos theory is applied to the context of project management and an attempt is made to design a new framework for managing versatile projects under unstable circumstances. Chaos in a project is defined as a state where project plans are updated or changed frequently and, moreover, no renewed plans are executed. Projects are potentially chaotic. Large stochastic simulations have been run in order to find out how to prevent the consequences of randomly varying durations, interdependences and correlations, feedback loops and the effect of unknown activities. The results of the simulations are presented in this paper. Some measures have been developed to keep a complex project (operations) on the edge of chaos. One should cut any feedback by using paced project planning, make the WBS independent through separate resources, prevent external effects by using partnerships, and set up an open grass-root communication system.

Keywords: Chaos theory, construction, project management, simulations

1. Introduction

In the 1990s, chaos theory was applied by many scholars in attempt to understand the organizations' ways of operating in extremely dynamic environments. In this paper, chaos theory is applied primarily to the context of project management. Traditionally, project management has been seen as a fairly stable and non-dynamic, linear process (see PMBOK, for instance). A part of traditional project management is risk management: risk identification, risk estimation (probability and consequences), risk response, and risk control. The requirement to estimate the probabilities of all indentified risks implies that traditional risk management is useless in a state of chaos. **Traditional risk management** does not provide us with answers in chaotic and unstable environments. By running this risk analysis, one usually find only the most probable risks coupled with small consequences, and organizations mainly plan their responses to deal with these kinds of risks. In reality, those risks that have big consequences and which have never occurred before remain unidentified.

In turn, **chaos** is a deterministic, non-linear, dynamic, fractal system that produces results which appear to be random. In a state of chaos, a system remains in a restricted area, but it has no equilibrium. In a chaotic system there are several factors, dependencies between these and feedback loops. Changes are irreversible. This description suits organizations well with inherent interdependent feedback forces. The well-known butterfly effect suggests that a chaotic system is sensitively dependent on its original state (and thereby also sensitively dependent on any of its states). In particular, the behavior of project management organizations has traits of vulnerability. In bifurcation, the state of a system is suddenly split into two states. Consecutive bifurcations create chaos. Organizations change due to bifurcation. Development paths are unpredictable. An attractor is a state to which a system strives to re-establish. We are familiar with the habits of organizations to revert back to 'the old way' of doing things despite management's efforts to make changes. Chaotic organizations have so-called "strange" attractors (or states), that they try to achieve. Herein, the term chaos is used quite freely to mean 'uncertainty' and 'instability' as opposed to stable conditions.

The rationale of the paper is as follows. First, chaos is dealt with in both the case of managing an organization and a project. Second, the results of four large simulations are reported on. Third, an attempt is made in order to design a framework for managing versatile projects under unstable circumstances. The reasons for the authors interest in managing projects in chaos stem from the turbulent and unpredictable construction conditions in Russia. Finally, the validity and the consequences of the proposed framework for advancing construction project management are discussed.

2. Chaos within an Organization

Thiertart and Forgues (1995 [1]) have presented **the following hypotheses** about organizations and chaos:

- Organizations are potentially chaotic due to feedback.
- A change from a stable organization to one in chaos happens unnoticed.
- In a state of chaos, small changes may have unpredictably big consequences
- In a state of chaos, new "strange" organizations are created on any level or process.
- The same action leads to a different result in different organizations and at different times.

The more actors, feedback forces, and different time spans of action an organization has, the greater the chance it ends up in chaos. An organization is always in one of three states, i.e. a stable state, moving in a periodically stable state, or in chaos. The moving state is called **the edge of chaos**. Organizations move from one state to another with consecutive bifurcations; i.e. by splitting in two parts. In a chaotic state, the long-term effects of a change are unpredictable. Identical measures within the same organization at different times lead to different results.

A chaotic organization constantly approaches strange forms. A chaotic organizational and process form has a fractal structure. A given chaotic organizational and process forms can be found at the corporate, department, and team levels.

The principles for keeping the operations of an organization on the edge of chaos consists of [2]:

- advancing with small steps and making short term decisions (trying to make a non-linear system linear),
- keeping simultaneously a track-record on what's happening at all levels of the organization and within all its processes,
- trying to detect the first bifurcation at any level or within any process; quickly expanding, and changing immediately your actions according to the perceived consequences.

In a chaotic environment, mere experience is not enough because repeating the same action that worked before does not necessarily result in the same outcome in a subsequent situation.

3. Chaos within a Project

Chaos in a project is a state where project plans are updated or changed frequently, and moreover no renewed plans are executed. Herein, the hypotheses of Thiertart and Forgues [1] are applied to a project as follows:

- Projects are potentially chaotic.
- The more parties involved and the longer the project, the more potentially chaotic it is.
- A project is always in either a stable or chaotic state.
- A change in relations between two or more variables may cause a project to move from a stable state into a state of chaos.
- The consequences of changes taking place in a chaotic project are impossible to predict.
- In a chaotic state, identical actions taken in the same or different project do not lead to the same results.

Internal chaos occurs when its source is one (more) of a project's own actors. When the objectives of an owner, users, or their needs change, disturbances emerge in financing and, thus, keep project plans in flux. On the one hand, poor project planning or control may also be a source of chaos or project planning and control would be means of controlling internal chaos.

External chaos is created by factors that are beyond the influence of the organization. An organization operates in an environment where changes are created, i.e. laws and the regulations of authorities change, deliveries are late, and the loyalty of employees is lost. Business environment seems to be chaotic if one does not understand the way it works. Thereby, the environment and the behavior of people in a foreign culture may seem to be chaotic to an expatriate, even if locals understand it well. There are no chaotic environments – just ignorance about the environment. External human chaos is thus prevented by a better understanding of the environment and the culture.

Chaos takes place in a project, when project control spots **non-planned events** such as (for instance):

- activities change and evolve,
- new activities are created and original ones are not executed,
- activities have to be carried out all over again,
- activities are not finished and everything remains incomplete or almost ready,
- there is a positive correlation between durations of activities,
- new interdependencies suddenly appear and external dependencies occur unexpectedly.

As a result, the objectives of the project are not met, timing fails, and costs get out of hand.

The traditional literature on project management emphasizes what should be done: plan, control, and make corrective actions. In a state of chaos, it is more important to have a general understanding **how to handle the situation** than what to do. Chaos is usually caused by people, not forces of nature, so the key questions should be: who, how, where and when – not what. For preventing chaos, one should thereby ask **WHY things can go wrong**, not WHAT can go wrong? This means that one should understand the mindsets and goals of the project participants as well as the environment and culture in which one operates. This may require an “adapter” (“facilitator”), a cultural interpreter.

4. Why Does Traditional PM Not Work in a State of Chaos?

In projects, a traditional tool of activity analysis is the Work Breakdown System (WBS) and the other tool for scheduling is the network planning technique (PERT). A careful breakdown of a process is of no use if activities within it are unknown, nor does the network approach approve feedback loops. In addition, correlations between activities are often not taken in account in planning and risk analyses. **The traditional PERT or the risk analysis** works if external disturbances, feedback loops, and internal correlations are ignored. In turn, neither works in a state of chaos or on the edge of chaos.

At the TKK/CEM, project scheduling has been simulated stochastically (Monte Carlo) in a number of ways during a long period of time as follows:

- Preventing consequences of randomly varying durations (Vehkaoja J., 1989 [3] ; Porkka-Aarnivuo S., 1989 [4])
- Preventing consequences of interdependencies and correlations (Simppa model) (Ristikartano P., 1994 [5])
- Preventing consequences of feedback loops (Ericsson H., 1999 [6]).
- Preventing a chaos state in complex construction project (ATOSim) (Ristikartano P. 2002 [7])

In these simulations, a feedback loop is described by a positive correlation between the durations of the activities. A positive correlation means that if the preceding task is late, the following task will take longer to perform as well. In a similar way, **project control** can be described by a negative correlation: if the preceding task is late, the duration of the following task will have to be made shorter.

Some key results of the TKK/CEM simulations are as follows.

(a) **In the context of project division, stages, and activities,** a project has to be cut into stages so that disturbances can be "squeezed into seams". Long peaceful activities that can be corrected should be preferred. Starting activities in intervals so activity planning can be done are preferred, and buffers are reserved at the end of the stages.

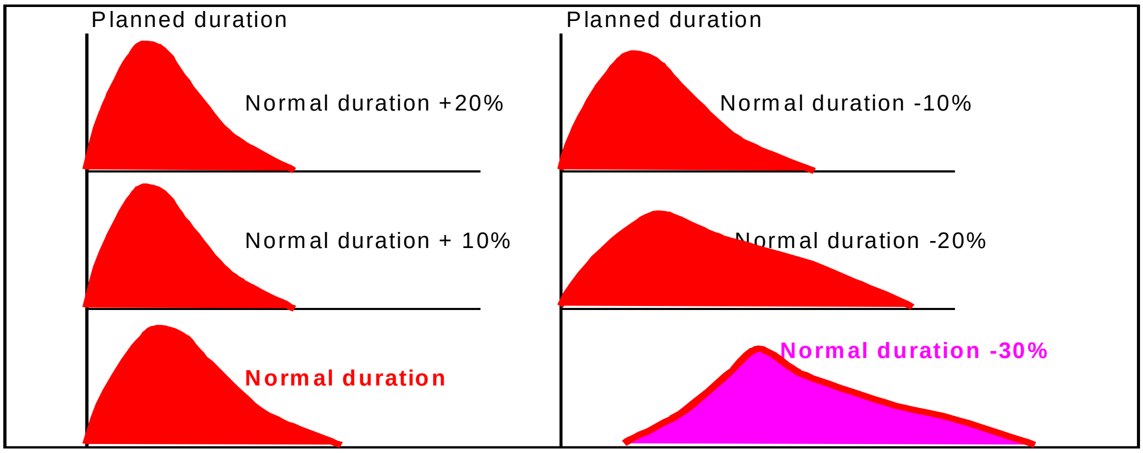


Figure 1: The distributions of the total durations when the schedule is extended or shortened. First chaotic features appear when shortening is 30%. (Vehkaoja 1989).

(b) **In the context of control, dependencies, and correlations**, even a small positive correlation leads to chaos, if control is not exercised, resulting in great variation. The use of the same resources for subsequent activities that cause positive correlations should be avoided. The control of workplaces is more efficient than control of the resources, and even a reasonable negative correlation, i.e. constant control is enough.

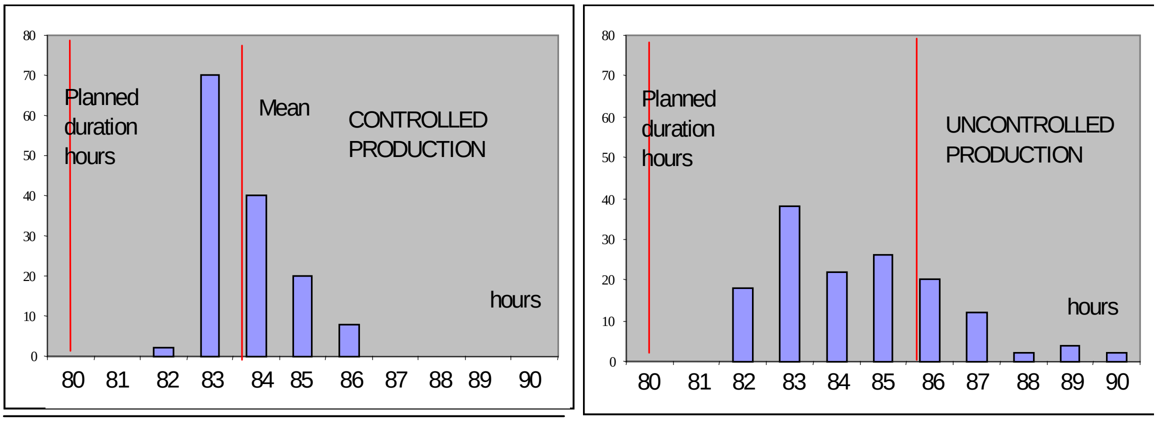


Figure 2: The distributions of the total durations (in hours) in the simulation of repetitive short throughput time (2 weeks) renovation of flats.(Ristikartano 1994). Control actions work well.

(c) **In the context of feedback and loops**, loops lead to bifurcations and spread out the duration of the project. Even if the probability of the loop is low, it will result in chaos and early signs of chaos are be seen as small trembles in durations.

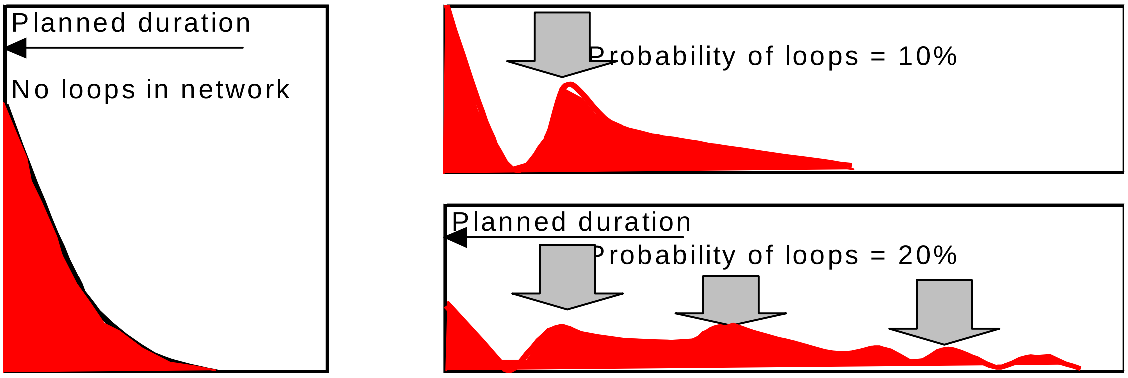


Figure 3: The distributions of the total durations in the simulation of the effect of loops in a schedule. If loops occur, the project is falling into a state of chaos.(Ericsson 1999).

Over the years, we have applied these results to practice when developing (among other things):

- A work sections technique for construction projects.
- A model of balanced schedules (advanced LOB) for construction projects.
- A model of short throughput times for repetitive projects.
- A staged execution model for a project in a chaotic environment.

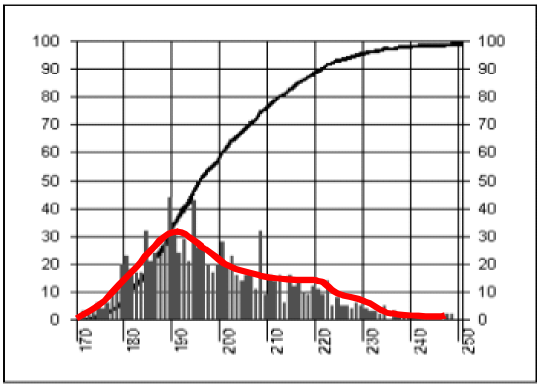
5. Results of Advanced Schedule Chaos Simulator ATOSim 2002

The most recent research tool is called ATOSim from the year 2002 (Ristikartano [7]), **the advanced schedule simulator of the project.** The simulation model describes the effects of the duration variation and the starting disturbances of activities. Furthermore, it tries to capture also the effects of different control actions. With this model we have analyzed especially in what kind of conditions the project falls into a state of chaos and how the control can be used to repel the chaos.

The ATOSim model is based on the network technique and the Finnish place-time diagram (advanced LOB). The deterministic model consists of activities and their workplaces with durations, dependences between the activities, and external dependences. The statistic simulation factors of the model are the variation of the duration of activities, the probabilities and the duration of delays and the interruptions at the beginning of the activities, and the probability of the external dependences. As it is normal in the Monte Carlo simulations, the model gives the distribution of the total duration of the project as a result. During the research work, over 100.000 networks were calculated altogether.

In addition there are resource correlations between activities (the same resources are used). Control actions are described by the activity level and the project level. In the activity level control, the durations of activity in question is reduced. In the project level control, the durations of the remaining activities are changed. In the simulation, we tried different probabilities of internal and external disturbances, different schedule solutions, and different forces of control actions. The productivity disturbances were measured by the waiting time of resources.

Uncontrolled Production



Controlled production

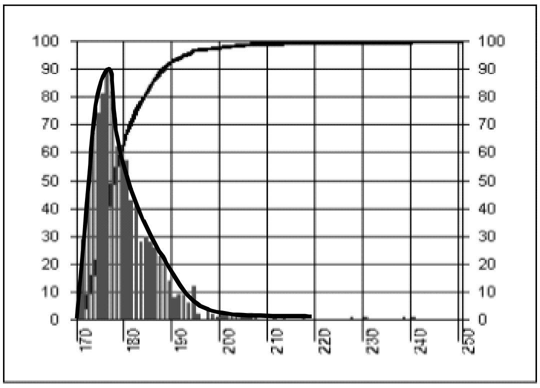


Figure 4: The distributions of the total durations in the simulation of the effects of the control actions. (Ristikartano 2002).

A probability of interruptions affects significantly the variation of the total duration. It does not depend upon whether it results from the late start of activities or from the external dependencies. The tight activity control degreases the variation. Continuous control actions have to be carried out. Productivity weakens rapidly when disturbances increase. Chaos is created when the probability of interruptions is high. Chaos is seen as both the lengthening and the large variation of the total duration, especially as the peak-less distribution of the duration.

In the schedules, the place of the buffer, the solutions of the critical activities, the number of the workplaces and the number of activities were varied. The buffers have to be placed at the end of the project or in the seams of the stages. However, the durations of tasks should be dimensioned tightly. There must be a lot of workplaces in the plan so the control has time to become effective. However, there should be fewer and bigger activities so that enough buffer time are obtained in the same total duration.

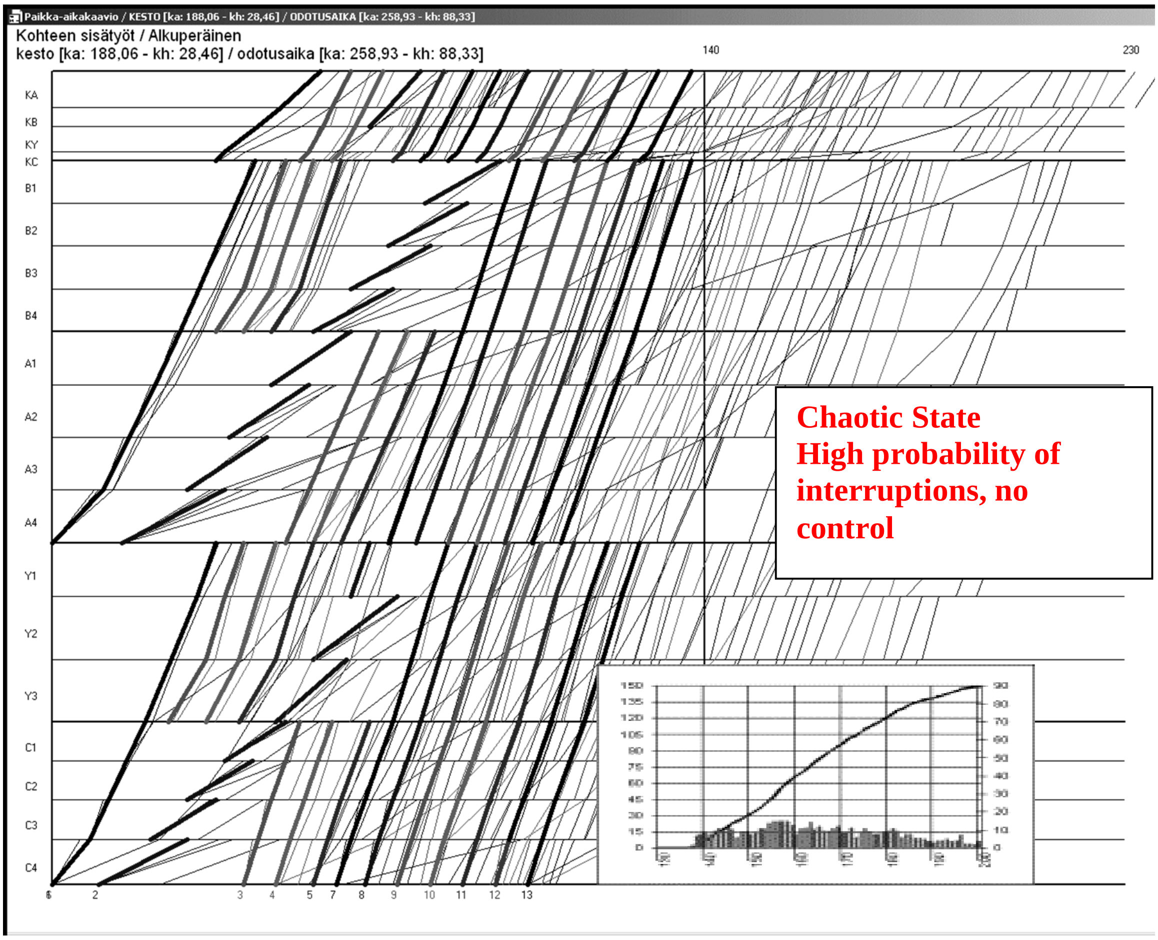


Figure 5: The place-time diagrams and distribution of the total duration in the simulation of the state of chaos. The thick lines are the planned schedule and the thin lines are the results of some simulation cycles. (Ristikartano 2002).

In the simulation model, the chaos is identified from the **form of the distribution,** which is nearly even (it does not show a clear peak). Furthermore, the clear growth of the waiting times is perceived. If the probability of a chaos is high, the production must be phased. In a workplace, the start of chaos can be repelled by isolating and condensing.

When **phasing** is used, the activities causing chaos are made ready before new activities are at all begun. In that case, the total duration is naturally prolonged considerably. When **isolating** is used, the resource dependencies are removed by using new crews and a workplace dependence is retained by preparing workplaces complete. In **sealing,** a workplace dependence is removed. This takes place by “jumping” over a workplace and moving the resources to the following workplace. The works of the “overjumped” place are then performed by separate resources (crew). When a probability of interruptions is high, it is not a big advantage to use balanced activities. It is then better to use the shipbuilding model in which "every workplace has separate resources".

6. How to Keep Your Project on the Edge of A Chaos

Herein, the initial framework for keeping a project on the edge of chaos is designed as **a set of rules for project management in chaos** as follows. In part, the generic rules are illustrated by the likely conditions in the Russian construction markets in the early 2000s.

1. Prevent feedback dependencies using project planning: Pace the project, divide it into stages and further into consecutive and independent activities. Divide the project into workplaces (production sections and areas). Interrupt the project immediately if a crisis takes place. Fix the problems of the preceding stage as a part of the next stage.

2. Make the WBS independent: Plan the work and procurement packages carefully with the proactive prevention of a chaotic state in mind. Packages should be independent from one another. All procurement packages, especially local or from a third country, should have pre-negotiated back-up contracts, respectively.

3. Prevent non-linearity by control: Control all the small tasks and on a short time span, change course immediately when needed. Have weekly meetings, make a special activity plan for each activity before its execution. Make pilots or models of new and difficult things beforehand.

4. Prevent the first bifurcation by ”fractal” control: Strive to detect the first weak signs of bifurcation. Exercise control of actual activities down at the site level. Control simultaneously all parties at all levels and in all processes. Act immediately when a problem is encountered. Do not put trust only in the compiled reports of the project as a whole.

5. Prevent external effects by using partnerships: Try to identify the influential stakeholders and enter proactive partnerships with them in advance. Align cultural differences by using cross-cultural and professional ”interpreters”. Use local designers for help. Listen to the local authorities.

6. Set up an open communication system: Create a fast, simple, and open communication system and test its performance constantly. Assume always that “they” do not understand. Coach and train your partners by a joint information system. Do not arrange academic lectures or teaching.

7. Support your goals with ”cultural” incentives: Clarify to other parties what outcomes you want the organization and the project to perform. Create rewards so that each culture accepts these as incentives for the joint realization of your goals. Try to support the egos of other decision makers, not your own.

Pacing the project squeezes chaos together. Chaos may occur in separate stages, but it does not move forward to the next stage. The results of a previous stage must be approved by all parties before the start of the next stage. Pacing causes longer total duration. This pacing procedure has been used in construction projects in Russia.

Non-linearity and a sensitive dependence of an initial stage are prevented by linearization, proceeding in small steps and, thus, making effects immediately known. In the suggested project management in a state of chaos, this means continuous planning and controlling instead of the traditional project planning before a start and reporting during it.

7. Conclusions

Herein, the validity and the consequences of the proposed framework for advancing (construction) project management are discussed as follows.

In these simulation studies, it was noticed that **schedules with different risk levels** can be made for the same project. The activities must be dimensioned right, they must be balanced. Especially, the whole schedule must be controllable. A tight control of the schedule reduces the risk of exceeding the scheduled duration and having a lot of waiting time. The control actions have to be made immediately and continuously. When more certainty is wanted, some **buffers** would be used. However, this extends the total duration of the project and increases costs.

At the beginning of a project, there are many possible completion dates. Different schedules can be made for the same project and the execution can be controlled in different ways. The schedule is fulfilled as such only if everything goes according to the plan. However, this does not happen in reality. The planned completion date is not necessarily even the most probable completion date. The Monte Carlo simulation can be used to test these alternative schedules. As a project proceeds, the disturbing factors are realized and they cause waiting time, the lengthening of the total duration, and the need for additional resources. In the worst scenario, a state of chaos is created which leads to repeated planning. The project reporting as typically found in textbooks does not help at all in a chaotic situation. All activities must be controlled from the grass-root level to avoid chaos.

To repel chaos, **an advanced planning system** [8] must be used in which the workplaces and the coarse general planning are combined, the detailed activity planning ís done just before the beginning of each activity, and a short time rolling window is used troughout the whole project. The corrections must be performed immediately. If work stops in one workplace, it should be jumped over immediately and a new team would be put in place.

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A Critical Review of Construction as a Project-based Industry: Identifying Paths Towards a Project-independent Approach to Construction

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Abstract

Construction is dominated by project-based production, and production organisations are constructed from relatively independent participants joining in constantly changing one-off coalitions of firms. This has influenced the industry's structure and methods leading to a highly fragmented sector with many different types of firms. As a consequence, the level of complexity of production in construction is relatively high and efficiency levels are relatively low. In this paper, construction as a project-based industry and construction as a project-based one-off undertaking are critically reviewed. Alternatively a more project-independent approach to construction is discussed and assessed, whether this would be more beneficial, for what kinds of construction, and under what conditions. First construction is characterised as a project-industry and the complexity of the sector is explained, including specific characteristics and contextual and structural features, as well as the benefits, basic problems and generic effects. Next reasons and rationale for project-independent construction are discussed, and paths to project-independent construction and supply chain integration are identified, both from the client and the supply chain perspective, for different sector in construction. Finally a possible future perspective is given on construction when developing towards a more project-independent industry.

Keywords: Construction, industry typology, project-based industry, project-independent production, supply chain integration.

1. Introduction

In contrast to manufacturing, construction is by nature vary much dominated by project-based one-off approaches and "pull"; often every project is different and delivered to a different client. In recent years, manufacturing has moved from process-driven "push" to more client-driven "pull" and to some extent a more project-based approach to production. Still, manufacturing has been dominated by a search for even higher levels of efficiency and alignment of supply chains through long-term but flexible relations between firms. In this paper, this path is inversed for construction – from a project-based to a project-independent approach – but aimed at the same goal: higher levels of efficiency and alignment of the supply chain.

The characteristics of the industry have often been observed and criticised, and in by some it was even questioned whether construction is actually an industry [1], or rather a “loosely coupled system” of projects [2]. In these observations the nature of construction and particularly the strong project focus within the industry has often been identified as a basic cause of many of the limitations and problems of the industry [3]. Some have identified specific peculiarities of construction causing the problems, including the temporary organisation, one-off product and site production [4]. Construction projects have been described as coalitions of firms; ‘a number of independent firms coming together for the purpose of undertaking a single construction project and that coalition of firms having to work as if it were a single firm, for the purposes of the project’ [5]. Alternatively, the parties involved in construction projects have been interpreted as ‘organisational units joining and operating together as a single production organisation when it is advantageous’ [6]; a ‘temporary multiple organisation’ [7]; or a “quasi-firm” [8]. However, there are significant differences between different types of firms in terms of what they regard as important to project success. The determinants of project success are not always straightforward and unambiguous [9].

2. The Nature of Construction as a Project-based Industry

2.1 Typology of Industries: What Kind of Industry is Construction?

Characteristics of project-based industries vary from industry to industry. The production system of each industry has been shaped by the industry characteristics and history. Project production systems in project-based industries are aimed at a product mix that is ‘one of a kind or few’, process patterns are ‘very jumbled’, processes segments are ‘loosely linked’, and management challenges are dominated by ‘bidding, delivery, product design flexibility, scheduling, materials handling and shifting bottlenecks’ [10]. In addition, the fragmentation of the construction industry has been identified since decades as a major point of the complaints about the state of practice [11], reflected most characteristically by the predominant one-off approach in construction projects, or ‘unique-product’ production [12].

Construction can be typified as a specific kind of project-based industry. Construction has been related to engineer-to-order products (ETO) viewing construction as a type of project-based production system, rather than a type of manufacturing, referring to Assemble-to-Order (ATO), Make-to-Order (MTO), or Make-to-Stock (MTS) types of production system. ‘Treating construction as a type of manufacturing obviously neglects design, and arguably subordinates value generation to waste reduction, which inverts their proper relationship’, however ‘certain aspects of construction should move into the realm of repetitive making’ [13]. Production system types of different industries could be dominated by either (one-off) designing or (repetitive) making (Figure 1).

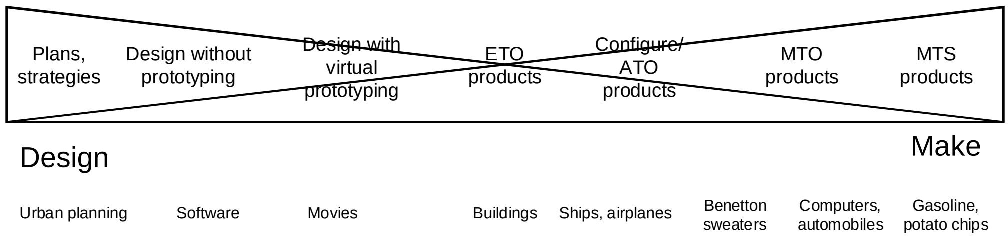

Figure 1: Production system types [13]

The production situation in construction could also be related to assemble-to-order production and "capability oriented production" systems [14]. Alternatively, construction could also be observed as a make-to-order, design-to-order, or even concept-to-order kind production system [15]. The characterisation of the production system of construction is largely dependent on the view taken and the definitions used.

When observed from a make-to-order perspective, the main management challenge is to capture the client order, avoid problems on interfaces in the supply chain and reduce time buffers in the information and materials flows [16]. In addition, compared to other project-based industries, whether it is site installation of prefabricated parts on site or mere on-site production, production in construction is always locally bound and dependent on physical factors such as soil and weather conditions. In addition, compared to most other project industries the volume and repetitiveness of projects in construction is mostly extreme low. The organisation of production and the supply chains is strongly adapted to these basic characteristics, and aimed at the convergence of logistics to one site, and delivery of the one-off, and often highly customised and capital intensive product to a single end customer [17].

2.2 Cultural, Structural and Management Characteristics of Construction

The culture in construction is rather multiform and inhomogeneous, caused by the relatively high fragmentation of the industry in different types and sizes of firms, and necessitated by the varying organisational configurations of projects. The culture within construction is a typical "project culture" and is often relatively informal compared to the often more formal "corporate culture", which has dominated in other industries such as manufacturing. The high status of projects explains the existence of two cultural identities within the construction industry: the corporate culture (office), and a distinctive culture within each separate project. The rather strong disconnection between the more regulated office environment and the less regulated project environment often disables corporate innovation programmes effectively reaching the production on site (project). However on a construction site workers are continually producing new solutions to problems that occur on site every day, but may be taken for granted, and not regarded, managed and communicated as an innovation. This explains why construction industry is deemed being less innovative than for instance manufacturing. The fragmented production system, strong influence of project culture, relatively weak corporate culture, and lack of shared values particularly among subcontractors is also regarded as a reason for the low customer focus and lacking possibilities to achieve value for the client. Main contractors must try and manage the rather random nature of subcontractor, which is amplifying the negative effects of project culture. Improved relationships, increased levels of supply chain integration and partnering with subcontractors should be aimed at increasing the identification of subcontractors with the main contactor's values, culture and the ultimate goal to achieve project success and customer value [18].

The structure of the construction industry has been rather fragmented, including many SMEs. Project characteristics differ noticeable across project-based industries. Usually the normative resource in construction projects is the budget and the completion date. The project success measure is cost, and completing the project by the scheduled date is often the most important scheduling objective [20]. Although this will be not quite different in various other project-based industries in general, there are differences in scope, for instance in the movies and software industries, where the emphasis is far more on the profits to be made when a movie or software is distributed and rights and royalties are yielding revenues.

Because of the central role of projects in construction, the project management function and the project manager have an important role. The project manager has the responsibility for the design as well as the execution, matches the project and the customer needs, and takes care of the entire production management. The dilemma is that the more complex and large the project is, the more empowered the construction manager must be to exercise control and authority, but also the more he should delegate and trust his people [21]. The type of project management in construction differs much from other industries. The standards and models used in construction industry are relatively basic and tend to have similar characteristics for all types of projects, compared to many other industries. The relatively low level of competition and the economic stability in construction have played a role here [22]. Compared to manufacturing, project manager qualifications, project size and uncertainty characteristics are found to be relatively low in construction [23]. In terms of quality management, significant differences have been found between industries regarding to the level of quality management implementation and quality output performances [24]. Levels of quality management implementation and the emphasis on quality management in construction companies is relatively low compared to utilities and service companies. In construction the attitude tends to be oriented towards conformance to contractual specifications and not gaining additional financial benefits or competitive strength from quality improvement. Construction has been to be less customer-oriented or responsive, but oriented more towards production and getting the work done on time and within budget. Particularly in construction the management challenge is mainly focussed on projects, which together with the relatively informal culture, and the fragmented structure of the industry as a whole as well as the production system, causes basic differences with other technology-driven industries, and particularly with non-technology industries (Table 1).

Table 1: Construction compared to other technology-driven industries and non-technology industries [25]

	Construction	**Other technology-driven industries**	**Non-technology industries**
Culture	Informal	Formal	Dynamic
Structure	Fragmented	Consolidated	Integrated
Management	Project driven	Process driven	Customer driven

3. Project-independent Construction

3.1 Problems and Deficiencies Caused by Construction Nature

Basic characteristics of construction cause limitations to technology and problems to management [3]. The limitations and problems have been found to be very closely related to the nature of construction. Basic problems in the construction supply chain are caused by construction peculiarities. These may be called endemic problems that are difficult to resolve, including the causes behind them and the deficiencies stemming from them [26]. In most analyses, fragmentation of the industry and the predominant one-off approach to production are indicated as major characteristic as well as problematic factors. However, paradoxically, fragmentation, meaning involvement of many different specialised firms in projects, does not need to be associated with low levels of efficiency, but instead may increase efficiency of resource allocation and speed of information exchange between parties, particularly in the post contract period of construction projects. But still, these benefits combined with long term relationships are found to provide the potential for further benefits for supply chain parties involved [27].

3.2 Reason and Rationale of Project-independent Approach to Construction

From the notion that the one-off approach in construction is a major problematic factor, a more project-independent approach to construction has often been advocated explicitly and implicitly. Project-independent approach have been suggested, dependent on the construction sector to which it applies, varying from modular product concepts and pre-engineered housing concepts, to multi-project procurement. The usefulness of applying concepts from other industries has been discussed and demonstrated many times, for instance between automotive and housing [28]. It has been discussed also that translation is needed when studying the possible transfer and application of “exotic” concepts to a construction context [29].

The basic shift from a one-off approach to a project-independent approach in the construction supply chain is to stabilise the project and production environment, and achieve operational and competitive improvements across projects and firm boundaries. In that sense, supply chain integration and management play an important role to achieve project-independent construction.

From a client perspective this must be achieved through altering procurement strategies, and from a contractor/supplier perspective through altering production and marketing strategies, to increase the level of integration and alignment between the different "stages" in the supply chain, e.g. between the materials supply and the construction site (Figure 2).

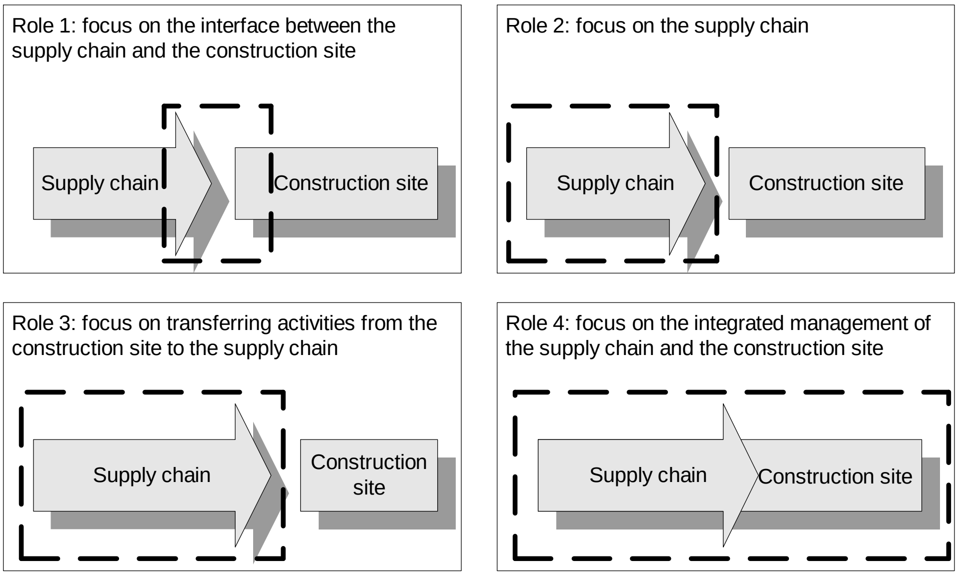

Figure 2: Four roles of supply chain management integrating materials supply and the construction site [26]

4. Paths Towards a Project-independent Approach to Construction

4.1 Client Driven Initiatives Towards Multi-project Procurement Strategies

Since construction is still project driven, obviously, there is lack of comprehensive guidelines for managing multi-projects in construction [30]. However, some advanced and "professional" clients with "buying power" can and have created multi-project environments and manage their procurement through a programmed or "portfolio" approach, based on the repetitiveness and similarities between multiple projects and the degree of project certainty within a programme [31]. In some cases, clients have successfully introduced a strategic long-term approach to procurement, which has proved to be particularly effective for certain sectors in construction [32]. Through these strategic approaches, clients have integrated project activities and procured these packages to integrated supply chains or "clusters" for longer periods of time by applying alternative procurement methods, such as prime contracting and framework agreements, and alternative contract formats, such as PFI en "DBFMOT" kinds of contracts [33].

However, the majority of clients are not in the position to exercise power over the supply chain, because they are too small or their portfolio of projects is, but also because of ad hoc procurement methods and sometimes misunderstanding of the marketplace. A lack of continuity of relationships hinders gaining the full advantages of long-term collaboration and transfer of experience and knowledge across projects [34]. Clients who have the power to alter their procurement strategies vis-à-vis the marketplace are in the position to align the supply chain effectively, and implement supply chain integration successfully [35]. Performance and financial incentives are to be applied by clients to the whole team, sharing pain and gain, relying on the positive effect of long-standing supply chain relationships [36]. Ultimately, the incentives are aimed to reinforce relationships and commitment, and foster trust for longer periods of time, which cannot be achieved through one-off approach to single projects [37].

4.2 Supply Chain Driven Initiatives Towards Project-independent Production Strategies

At the supply side, parties may evolve towards more integrated production and business formats, through project-independent collaboration with neighbouring parties in the supply chain as well as internalisation of neighbouring activities of businesses. In both cases operational and competitive advantages, through higher levels of productivity and efficiency as well as delivering better client value must be the drivers for this kind of supply chain integration. In the case of vertical integration, often the so-called make-or-buy decision is often dominant whether or not to internalise or outsource a business activity. In practice consequences of integrating or outsourcing activities are not always clear. Often this is driven by mere economic arguments, but for successful business integration need to observe more relational aspects between firms than economic aspects only [38].

Companies in different industries, including automotive, but also construction, where design information and new product development play an important role, could benefit from applying multi-project strategies to design information and product development activities, reusing information, components and establishing long-term relations with closely linked parties, including suppliers, resulting in competitive and operational advantage in relation to competitors [39]. In same cases, these kind of inter-organisational formats are referred to as modular production networks, where fixed relations and reuse and interchange between standard components and firm in the supply chain (production network) are the basis of speed and flexibility of assembly, and this collective competitive advantage [40]. In construction the modular approach to product development, including flexible customisation and postponement of decisions, has been reflected by the concept of open building, including integration is trades and the supply chain, and project-independent approach to construction [41]. Generic project-independent production strategies, such as platform strategies and modularity, in some cases, particularly housing, have thus demonstrated to be possible as well as beneficial [42].

4.3 Differentiating between Sectors of Construction

Construction is consisting of various relatively different and disconnected sectors. As such *the* construction industry does not exist. Per sector possibilities, obstacles, paths and implications project-independent construction are different. Here, three major sector are distinguished: housing, commercial building (offices etc.), and civil (roads, railways etc.). Per sector client driven and supply chain driven initiatives can be identified in construction practice (Table 2). Besides many different other sectors may be distinguished.

Table 2: Differentiating between client driven and supply chain driven initiatives towards project-independent construction in different construction sectors

Initiatives towards project-independent construction	Client driven	Supply chain driven
Housing	Individual clients generally lack power to integrate the supply chain; large housing corporations may develop a supply chain strategy	Supply chain parties may engage in strategic collaboration to develop and introduce pre-engineered housing concepts to the marketplace
Commercial building	For instance real estate developers or large companies may involve integrated supply chains for their real estate stock	Supply chain parties may join to develop multiple commercial buildings, however commercial risks and variability of design etc. may be too high
Civil	Particularly public or semi-public clients may introduce portfolio procurement strategies for multiple projects	Supply chain parties may deliver multiple integrated projects, but mostly initiated by the client; but not through pre-engineered concepts

5. Future Perspective on Construction: Project-based or Project-independent?

5.1 From One-off to Repetitive Construction?

Still construction is dominated by one-off approaches and ad hoc production organisation. Many projects are being planned separately from others, even within one construction company, or client. Traditionally this is mainly because many projects are unique, or regarded to be unique. Particularly large projects are complex undertakings involving a vast spectrum of demanding (clients, users, stakeholders etc.) and supplying parties (contractor, subs, suppliers, consultants, architects etc.). For these kinds of projects in specific sectors of construction, project-based working will stay to be the dominant management format. However, in some sectors, in some cases, clients or contractors or other parties in construction have developed such procurement, business and production strategies that aim to increase the repetition between projects, within the own organisation and for the own business, or with other parties in strategic cooperation arrangements.

5.2 From Construction to Manufacturing??

Some companies in construction (contractors, specialty contractors, suppliers etc.) have increased the repetition factor between projects by developing and introducing complete product concepts (e.g. housing concepts), or integrated components of building (e.g. integrated facades for offices), to the marketplace including all engineering, parts manufacture, logistics and site assembly, rather than delivering one-off projects, based on mere project specifications. To certain extent these companies have redefined their traditional business and processes towards a manufacturing kind of format. In construction practice, one can see that these companies choose to be excelling in a certain niche market, where they think and mostly succeed in being successful in terms of achieving higher productivity and profit levels, compared to traditionally operating competitors.

5.3 Implications for the Construction Supply Chain

The increase of repetition and move towards project-independent construction has considerable consequences for the supply chain. When taking initiative towards project-independent construction, one or few parties in the supply chain will increase their power and leadership vis-à-vis other parties in the supply chain through strategic collaboration or integration of businesses and activities. As a consequence the level of integration will increase and the level of autonomy of parties in the supply chain will decrease. Clients who take initiative to project-independent construction and supply chain integration arrangements will generally involve teams for longer periods of time, e.g. through prime contracting and framework agreements. Supply chain parties who take initiative to project-independent construction and supply chain integration will generally need to concentrate their business to certain niche markets and integrate all activities needed to deliver complete products to the marketplace, either concentrate on core capabilities within strategic collaboration with other supply chain parties in order to deliver integrated products to the marketplace collectively.

6. Discussion and Conclusion

The construction industry has traditionally been dominated by project-based one-off production. Often the traditional approach to construction, particularly the one-off approach to projects and the fragmented structure of the industry has been criticised for not being efficient. For most kinds of projects and sectors of construction though, the project-based approach is logical and sometimes inevitable, particularly for large civil projects. However, for smaller kinds of projects, in certain sectors, and by developing an alternative strategic approach to procurement or delivery it is possible to achieve project-independent construction to different extents and in different forms. Both clients and supply chain parties may choose to follow the path of project-independent construction. This requires certain strategic decisions and playing another role in the supply chain, and higher levels of supply chain integration, through internalisation of more activities or through strategic collaboration with other supply chain parties.

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Construction as Production by Projects

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Abstract

This paper responds to the invitation to debate the theory of production in construction from the advocates of lean construction (LC), and in particular, to their critiques of the theory of project management represented in the PMI's PMBoK, and the "economics-based" approach to construction project management presented by Winch. The paper reviews the theoretical and practical contributions of LC before moving on to address the specific criticisms made. The paper then suggests that LC theory has its own limitations and requires further development in the areas of the definition of process, the concept of organisation, the theorisation of risk and uncertainty, and its unitary concept of value.

Keywords: Lean construction; construction project management; transaction cost economics; value; risk and uncertainty.

1. Introduction

The organisation of the construction process is the subject of intense debate and intensive research in a number of countries. The aim of this paper is to respond to the invitation to constructive dialogue from the advocates of lean construction (LC) and, thereby, to move the debate onwards in the development of a perspective which views construction as a distinctive mode of production by projects. Lean construction (LC) synthesises an original perspective based on a *transformation/flow/value* view of the construction process with distinctive operational methods such as the *last planner* approach to construction project planning. In sharpening their development of the concepts, explanations, and implementations of LC, its proponents have developed a number of critiques of different perspectives on the management of construction projects. Engagement with two of these critiques in this paper, it is hoped, will facilitate the development of a theory of production applicable to the construction process to move on. These are :

- the critique of the economics-based approach [1]
- the critique of project management theory [2]

2. The Theory of Lean Construction

The work of Lauri Koskela is an ambitious attempt to provide a theory of production applicable to construction. His principal contribution is contained in his doctoral thesis [3], and elaborated in a number of subsequent publications [e.g. 4, 5]. Koskela's thesis draws on a wide range of literature in production and operations management to develop a three-part theory of production which he calls transformation/flow/value (TFV). The literature review identifies three different perspectives on the production process that have been deployed during the 20th century – the transformation concept; the flow concept; and the value concept.

The *transformation concept*, Koskela argues, focuses on the transformation of materials from one state to another. Economically, it is associated with Walras' production function, while in production terms it is associated with the scientific management approach of people such as Taylor. Its basic tenet is the detailed pre-planning of the production process which is broken down into a series of tasks, each of which is progressively optimised. One result of the concern to optimise individual task execution is the recommendation that tasks with different characteristics be buffered from each other. While this approach has many advantages, particularly associated with the development of sophisticated production technologies, it also suffers some significant disadvantages such as rising costs of work-in-progress created by the buffers, the risk of sub-optimisation at the system level, and inflexibility in response to changing market demands. So far as the design process is concerned, the transformation concept is represented in attempts to standardise the design process and to apply project management techniques.

Koskela argues that the *flow concept* takes a very different approach. Here the principal influence is the Toyota Production System. From the flow concept point of view, the objective is the minimisation of waste. Analysis of work flows designed around transformation concept principals reveals that materials typically spend very little time actually being transformed, and most of their time waiting to be transformed, being moved, or being inspected or otherwise controlled. The argument is that by focusing on reducing time taken to flow through the manufacturing system as a whole, greater economy can be obtained than by focusing on the efficiencies of particular sub-processes. The key to this reduction is to reduce variability in the execution of particular sub-processes rather than to increase their efficiency. Coupled with simplification of production processes, this attention to cycle time can lead to greater flexibility as well as greater system-level efficiencies. In the design process, the flow concept is represented in the use of concurrent engineering and related techniques.

For Koskela, the *value concept* derives from the quality movement originated by Shewhart and contributes by bringing the customer into the perspective. Flows and transformations of materials are only of value if the resulting product meets the needs of those who are expected to purchase it, and so the definition of customer requirements is central to the value concept. Once those requirements have been effectively captured in the design process, the role of the manufacturing is to meet the requirements processes of quality management and control. Within design, the value concept is represented in requirements capture processes where techniques such as quality function deployment are appropriate.

3. The Practice of Lean Construction

The TFV conceptual framework supports a variety of different tools and techniques that allow the principles to be applied to the management of construction projects as part of the Lean Production Delivery System (LPDS) [6]. The best known of these is *last planner* [7] which was developed “in-house”, and is a way of buffering task execution by only allowing those “quality assignments” which are completely ready to be started in the context of effective lookahead planning, and close monitoring of “per cent plan complete”. Other applications are taken from mainstream lean manufacturing such as value stream mapping [8], and from developments in design management such as dependency structure matrix [3], and in supply chain management [9]. A number of other organisational innovations are also recommended such as involving downstream players in upstream decisions; deferring commitments to the last responsible moment; aligning the interests of participants; and the effective use of buffers.

The last planner approach to construction planning is an important innovation, and anecdotal evidence suggests that it is diffusing well. Many of the other elements of the LPDS are widely accepted as having the potential to improve significantly the management of the construction project process. There are, perhaps, at least two surprising omissions from the LPDS toolbox. The first is the apparent lack of attention paid to new forms of organisation of the project to form the context for the implementation of the LPDS. For instance, the use of supply chain clusters based on Thompson’s [10] principle that appropriate organisation designs cluster together those functions which have the greatest interdependence, and hence the greatest requirement for mutual information processing. Different applications of this concept have been developed by Lahdenperä [11] and Gray [12], and applied with apparent success [13]. While Koskela [3] does discuss Lahdenperä’s new construction mode, and the *demarche séquentielle* [14], these innovative ideas do not seem to have been taken forward into the LPDS. A second is the lack of attention paid to the work of Goldratt – particularly the theory of constraints [15] and its project-specific application in *critical chain* [16]. Critical chain directly addresses the problem of slack in task execution time estimates, and suggests trust-based relationships as the solution, while introducing resource constraints into project planning – a revolution in a context when construction project planners have typically assumed infinite resources.

4. The Critique of the “economics-based” Approach[1]

In developing their concept of LC, its proponents have provided a detailed critique of what they call the *economic-based approach* to analysing production in construction [1]. They choose as

[1] All citations in this section are to [1] unless otherwise specified.

representative of this approach *Managing Construction Projects: an Information Processing Approach (MCP)* [17], and make a number of critiques to the effect that it :

- Focuses on transactions rather than production;
- Focuses on information flows rather than materials flows
- Places uncertainty reduction at the heart of the process
- Deploys a tectonic approach to organisation

4.1 The Focus on Transactions

The LC critique argues that the focus on transactions means it "views production as a series of transfers", and that it "disregards the flow aspect of production" meaning that production is "organized just on the basis of purchasing costs". These assertions display a misunderstanding of transaction cost economics (TCE), because transactions are defined as "changes in ownership" through "purchasing", and it is held that TCE argues that "those organizational forms that minimize transactions costs are in the long run preferred" [3 p. 104]. However, Williamson defines a transaction as occurring whenever "a good or service is transferred across a technologically separable interface. One stage of activity terminates and another begins." [18 p.552]. A technologically separable interface is one that is not constrained by the nature of the production technology – in other words, the production technology chosen does not foreclose the possibility of allocating two different parts of the production process to different parts of the organisation, or to separate organisations. Thus, the theory focuses on the question of whether to purchase or not - the classic make/buy problem - not on purchasing alone. Rather than being "fully compatible with the decomposition principle of the transformation model of production", TCE is – arguably - a critique of the focus on the costs of decomposed transformations alone, without taking account of the cost of coordinating *between* those transformations. Through a TFV lens, TCE can be seen as posing the question of how flows within and between organizations are to be organized – or "governed".

The argument that the sole focus of TCE is on transaction costs also displays a misunderstanding – "transaction cost economizing needs to be located with a larger economizing framework and the relevant trade-offs need to be recognized" (*ibid*). Thus, the fundamental insight of the transaction cost approach is that in order to economise on the total cost of a good or service, *both* production costs and transaction costs must be taken into account. While a traditional economic analysis can identify the most efficient choice of production technique, it cannot explain the most effective use of that production technique. Thus total costs are the sum of the costs of production and the cost of governing the transactions inherent in that choice of production technique. A production technique that has the lowest production costs might not be the economising choice if transaction costs are also taken into account[2]. The resolute focus on transaction costs rather than production costs in TCE research is simply a strategy of focusing on where it makes its distinctive contribution.

The structure of *MCP* is based on an earlier analysis [19] of generic project processes, and only one of the four generic business processes[3] is developed drawing on TCE. It is never argued that the costs of buying should be the sole basis for the organization of production in construction. The argument in *MCP* is simply that they need to be taken into account in a full theory of construction production, the conceptual link between the TCE contribution and the rest of the theory is made through construction project organizations being information processing systems. Unless the argument is that construction production should be organized in a fully integrated Soviet-style *Kombinat*, then the make/buy problem is central to the organization of production in construction and any theory of construction as production needs to include an analysis of how transactions in the flow of production are governed through markets, hierarchies and various hybrid forms.

4.2 Organisation as an Information Processing System

It is argued that *MCP* views “organization as only an information processing system [and] the production of goods and services, the *raison d’être* of the organization (in normal cases), is abstracted away”. Again, this is not the position argued in the book. The full argument is developed in [20] on metalworking production which fully analyses both information *and* materials processing and the relationships between them in terms of the information flows initiating and controlling the materials flows. However, MCP is about *project* management, which is, in essence about the *coordination* of the activities of all the resource bases mobilized on the project which are responsible for materials processing as well as a variety of information transformation tasks such as in design. This is made clear in [17 table 15.1], which summaries the differences in responsibilities between the project manager and the resource-base managers working on the project. *MCP* is not intended to cover how bricks should laid or structural joints detailed – these are the responsibilities of the managers of the resource-bases engaged to carry out these tasks. The task of the project management function is to coordinate these transformations so that they move into the flow of the project life-cycle. This coordination task is essentially an information problem – who should do the task, when they should do it, can it be started now, and has it been completed fully to the specification?

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[2] Winch [51] provides an analysis of UK rail maintenance projects arguing how the failure to take into account transaction costs in outsourcing led to serious inflation of total costs.

[3] These four are “defining the project mission”; “riding the project life-cycle”; “leading the project coalition” and, under discussion here, “mobilising the resource base”.

4.3 Uncertainty Reduction as the Principal Challenge

The objective of uncertainty reduction, it is argued, "in and of itself is not the objective, but it is rather a means for getting the facility built, generating value and reducing waste". I totally agree with this statement, but submit that the principal obstacle to achieving these worthy aims is the uncertainty pervasive to decision-making on the project. Construction project clients and their suppliers engage in a "future perfect" strategy [21] of conceiving where they want to be at a specified point in the future in terms of value added and budget spent, and then, in essence, working backwards from that point. We, by definition, cannot know the future, and so the journey through time from the present state which we can know about to that desired future state can be a long and fraught one, with many surprises along the way. Only to the extent that the past is like the future can the information that we already have tell us about the most appropriate path to take to that future, and we can never be sure how like the past the future will be. On some projects, this is a high proportion of all the information required, on others it is a relatively low proportion. Some elements of information, such as the structural properties of a specified steel can be expected to change little in the future; other elements, such as the condition of the ground are less predictable, while elements such as the spot price of bricklayers two years hence may be subject to considerable change. These factors are handled within the concept of risk – the condition of uncertainty where enough information is available to assign a probability to the occurrence of an event – but many aspects of uncertainty on projects are not amenable to the *meaningful* assignment of probabilities. They remain *unk-unks*. The vital issue that a project manager has to address is how representative is past data for the particular project that he or she has been asked to manage – a problem that is captured in the concept of "mission uncertainty" [17 p. 7].

The advocates of lean construction argue that "decisions in a project are ordered so that each decision is based on information produced in earlier decisions, and produces information, in turn, for subsequent decisions". This is true, but it does not then follow that "each decision can be made based on all information needed, without any uncertainty,"[4] because the information to hand is frequently only part of the total information required for the decision – this is Galbraith's [22] definition of uncertainty. Information is arriving all the time on the project as "news" about the possible range of future states [23], and some of it will not be as envisaged when the commitment to a particular course of action was made. The LC view of information processing on the project is inherently a backward looking one, and not one that looks forward to the completed asset that will generate value for the client. It is suggested that any remaining uncertainty can be reduced to variability and handled using analysis techniques such as queuing theory. Where this can be done – typically when operations are repetitive – it is of course advantageous to use queuing theory and related techniques derived from operations research. However, most operations on projects are not repetitive for the simple reason that this is why

[4] They do recognise that there are practical limitations to this condition – the argument here is about epistemological limitations.

they have been organised as projects. The whole point about projects is that they are about unique activities – repetitive operations are not appropriately organised in project mode. This, of course, begs the question of whether all construction production should be organised in project mode, and there are clearly some forms of construction production, such as housing [24], where this is inappropriate. It is also the case that repetitive transformations within a unique project such as shear walls [25] are appropriately organised in non-project mode. None of this gainsays, however, the fundamental argument that a construction project is essentially a proposition about a unique future state, and that uncertainty in decision-making is inherent to the process of achieving that future state.

4.4 The Tectonic Approach to Organisation

The tectonic[5] approach to organisations was initially developed in [20] and argues that information processing in organisations cannot be directly managed, but is managed through changes in organisational structure in terms of both internal and inter-organisational arrangements. The point is reinforced in MCP through the metaphor of the river where what is of interest is the flow of water which has the potential to provide power, transport, food and the like, but this potential is realised and enhanced by alerting the structure through which the water flows by constructing dams, weirs, bridges and the like. It is argued by the advocates of LC that "this approach neglects the management functions of (production) system operation and improvement". I submit that it does not, because production system operation and improvement – to the extent that it is about materials flows – *is* susceptible to direct management. Hounshell's magisterial history of the American system [26] shows how this was done during a profound revolution in manufacturing techniques. However, these changes in manufacturing techniques need to be placed in the context of the revolutions in business organisation which enabled them [27]. Manufacturing techniques for optimising materials flows can only function in the organisational context of the information flows that support them [20].

5. The Critique of Project Management Theory

Implicit in many of the responses in the previous section is a difference of perspective on the nature of project management and organisation. The advocates of LC have addressed these issues in a brave paper[6] [2] which takes the Project Management Institute's body of Knowledge (PMBoK) as its principal point of reference[7], complemented by reference to Turner's [28]

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[5] "tectonic" in this context means "a series of arts which form and perfect vessels, implements, dwellings and places of assembly" (*Oxford English Dictionary 2nd ed.*)

[6] Brave, because it was presented by Greg Howell at the Project Management Institute Research Conference.

[7] There are other project management bodies of knowledge which have much in common with the US one.

influential text. They argue that the implicit theory behind these texts is symptomatic of a focus on the transformation view alone where management is about planning, executing, and controlling in a cybernetic model of the process. This is particularly manifest in the decomposition of the total process inherent in the development of the Work Breakdown Structure (WBS).

Perhaps the most obvious critique of this position is that few – if any – researchers in project management take the PMBoK as a theoretical orientation for their work. PMBoK was developed as part of the strategy of achieving full professional status for project managers as the basis for certification programmes for aspirants. Its efficacy in doing this is debatable [29], but beside the point here. In the context of the debate about theory in project management it is an irrelevance, as most researchers would accept Morris' critique [30] of its limitations as a theory of project management. However, the LC critique cannot be dismissed as easily as this. The substance of their critique focuses on the centrality of the WBS in PM theory, because this forms the basis for the classic project management tools such as critical path analysis and earned value analysis. It is true that WBS is inherently a decomposition, but LC techniques also decompose the process in, for instance, value stream mapping [8 fig 2] and process flow charting [25 fig 8]. The point is not the act of decomposition, but what is then done with the decomposed structure.

In critical path analysis, the WBS is used to identify sequential dependencies between tasks and to indicate expected task execution times. This information is then used to find the longest route through the network thereby created which identifies the critical path, or shortest possible time for total project execution. The LC approach also requires this information, but applications such as MS Project provide it more neatly than in, for instance, process flow charts [25]. The other main type of information mapped in the LC approach is who is to do the work. Conceptually, the supplier of the task execution services is handled in PM theory within the organisational breakdown structure (OBS), and is implemented in the resourcing tables of MS Project. This information can then be used for resource levelling, as well as in the much more sophisticated applications of critical chain (which is a resource-constrained critical path) such as ProChain. Where operations are repetitive - such as in the shear wall and pipe support examples - scheduling techniques such as line-of-balance may be appropriate. The advantage of applications such as MS Project is that they add analytic intelligence to the process representations (e.g. critical path, resource levelling) which is absent from the LC applications. It can also be suggested that critical path network and line-of-balance are inherently about flows as work moves from one task to another. The choice of tools and techniques for process representation and analysis is a pragmatic one – the argument here is that there is no theoretical reason to reject those tools and techniques based on the WBS. A more valuable strategy would be, therefore, to follow Goldratt's approach of enhancing these tools to meet contemporary requirements, rather than to trying to develop new tools from scratch for use within the LPDS.

However, this debate about tools and techniques misses a rather more important issue – what is theory in project management about? Many of the comments above in response to the LC critique of *MCP* have implied that the there is a misunderstanding in what project management is about. The argument in *MCP* is that it is inherently an organisational innovation, a position derived from a reading of the history of project organisation [30, 31]. The tools and techniques which are so often synonymous with "project management" are simply that – tools and techniques, and not the core of what project management is about. Projects as a distinctive form of organisation emerged during the 19th century as society started to create complex systems, and were developed and formalised in the US aerospace sector in the post-war period. They are now rapidly diffusing in a large number of industrial sectors [32]. In a very important sense, they are a response to the transformation-orientated organisational forms that emerged with the development of new volume production techniques such as the American system and mass production. As Womack and Jones argue, "the concept of a project engineer to oversee the entire value stream foreshadows the lean principles described in this book" [33 p 156].

The perspective on project management underlying *MCP* draws on the work of authorities such as Morris [30] and Turner [28] to theorise project organisations as temporary systems for the definition and execution of unique, time-limited objectives which are capitalised by clients. In order to achieve these objectives on behalf of clients, project organisations mobilise the *resources bases* which act as the permanent repositories of the human and physical resources required for project definition and delivery. These resource bases may be internal or external to the client organisation – in construction they are almost always external. It is the resource bases which are responsible for the transformation of materials – project organisations and their managers are the coordinators of the flows of information that govern the transactions between resource bases and responsible for ensuring that the value originally identified in the investment appraisal for the project is captured by the client. This position accepts that not all construction production is appropriately organised in projects – housing production, for instance, is outside the scope of *MCP*. As the project organisation moves through the project life-cycle, project managers deploy a variety of tools and techniques for the planning and control of the flow of information that coordinates the transformation and flow of materials within and between resource bases. However, such a mechanistic approach is inadequate, and leadership remains essential for organisational and cultural coherence in definition and execution. MCP concludes by arguing that effective construction project management needs to be design led (i.e. focused on value for the client) and performance driven (i.e. focused on effective and efficient processes).

6. Engaging with the Theory of Lean Construction

The range of reference underpinning the TFV approach is wide and it is, perhaps inevitably, more syncretic than synthetic at this stage of its development. A review of the history of manufacturing and the application of its development to construction which provides the historical context for this critique is provided elsewhere [34]. I will leave also for others the task of detailed examination of the review and analysis underpinning the three pillars individually and in comparison, and focus in this paper on what I consider to be some conceptual weaknesses that all three conceptual pillars share :

- The focus on the physical processing of materials as an engineering problem;

- The absence of a concept of organisation in the analysis;
- The lack of any analysis of the implications of risk and uncertainty;
- The unitary concept of *value*.

6.1 Production as Materials Processing

The overwhelming emphasis – either explicitly or implicitly - of the TFV approach is on the processing of materials as a technical problem in engineering. This is manifest in both the selection of the sources for the development of the three pillars, and in the overall tenor of the argument. While attention to the physical processing of materials needs to form part of any theory of manufacturing for the production of artefacts, it can only form part of an overall theory of production for two reasons. The first is that not all production is of artefacts – many phases in the production process involve no physical transformation at all, and many firms in the construction industry supply services to the client such as consultancy rather than artefacts such as shear walls. Second, and more generally, important shifts are taking place in the market for manufactured goods, where, increasingly, what is purchased by the client is the service that the artefact provides, not the artefact itself, in *integrated solutions* [35].

Koskela's analysis does encompass design processes, but the notion of design appears to be limited to fitness for purpose defined in engineering terms as opposed to design as symbolic value defined in cultural terms. Clark and Fujimoto [36] argue persuasively, based on their extensive work in the automobile industry, that the essence of successful design is *product integrity* which has two facets. The first is *internal*, and is essentially the same at the familiar fitness for purpose criterion. The second is *external* and refers to the consistency between the product's performance and customer expectations which include measurable performance criteria, but also synergy with the customer's lifestyle and aspirations. Koskela does not argue that design is the same as manufacturing, rather he suggests from a value perspective that it is "analogous to mining…. The issue is to find the ore (requirements) and to have it processed so that no metal is rejected in slag (avoidance of loss), and to produce an end result with as little impurity as possible (optimization)" [3 p. 118]. This conceptualisation of the design process finds little resonance with the analysis of the design process articulated by such authorities as Lawson [37] as a messy process of finding solutions to wicked problems, and I submit, presents a very limited notion of what the design process in construction is about. Although more recent formulations by LC [6,1] have suggested that effective design has more emergent properties than this citation suggests, there is still a strong sense here of the now discredited [38] design methodologies approach.

6.2 The Organisation of Production

A notable feature of the principal contributions to current debates on the transformation in manufacturing associated with the Japanese challenge over the last 20 years is the considerable attention paid to organisational issues. The contributions from both Harvard and MIT which have led this debate all combine analysis of flows of information and materials with analysis of changes in forms of organisation. The reason for this is that processes cannot exist on their own – they are always embedded in an organisational context, and that context is as important an influence on how information and materials flow as the configuration of machine tools on the factory floor [20]. While it is certainly possible to analyse operational flows in isolation from their organisational context using techniques derived from operations research, any implementation of the results of such analysis, or indeed the implementation of any new technology designed to improve that process, requires organisational change to provide the context for the effective use of that technique [20]. This lack of attention to organisational issues is surprising given that last planner [7] is, in essence, an organisational innovation in that it proposes weekly meetings to determine which "quality assignments" can be scheduled for the following week's work.

This analysis of structure and process in organisations draws on the contingency approach to organisation design authoritatively reviewed by Mintzberg [39]. Despite its importance to research in the development of lean processes, the reference to this literature is both very limited, and a misinterpretation. The contributions of Thompson and Galbraith – two of the leading contributors to the contingency theory of organisation – are discussed solely in terms of their relationship to the transformation concept of buffering [3 p. 44]. The term does not appear in the index of Galbraith's major synthesis of his contribution [22], nor his more recent management guide [40]. The misinterpretation of Thompson's [10] discussion of buffering is of greater interest in the context of this paper, because Thompson's principal concern is how organisations seek certainty in the face of exogenous uncertainty in order to protect their technical core, and buffering of that core from the external environment is one strategy for doing this. In this sense, last planner is a classic buffer technique in that quality assignments are those assignments that have had the uncertainty associated with their execution minimised.

6.3 Risk and Uncertainty at the Heart of the Organisation of Production

This point leads us nicely to the third critique of the TFV which is the lack of any conception of uncertainty or risk, where risk is uncertainty to which a probability distribution can be assigned. A basic tenet of organisation theory is that one of the major – arguably the major – influence on the design of organisations and the production systems they support is the level of uncertainty that they face. This uncertainty may be environmental [41], technical [42] or transactional [43], but it is pervasive. It is particularly pervasive in project organisations due to their non-repetitive nature – indeed risk management is arguably the most important development in project management tools and techniques since the 1960s [30]. Stinchcombe [44] argues in his comparative analysis of the construction and car industries that it is the level of uncertainty that contractors face, and therefore, their need for flexibility that most clearly distinguishes them from car manufacturers.

One of the major changes in the environment for organisations and their production systems over the last 40 years since the era of the contingency theorists is that levels of uncertainty have increased as organisations' abilities to buffer themselves from those uncertainties have decreased. The dynamics of change in the market environments and technologies of production have intensified across all sectors, and construction and the other project-based industries face relatively high levels of uncertainty compared to other production sectors. I submit that any viable theory of production must have a concept of uncertainty at its heart – in other words, we need a theory of how production systems vary contingently with the levels of market and technological uncertainty that they face as part of any theory of production.

The fundamental role of uncertainty in the design of production systems means that information is critical. Uncertainty is defined as the difference between the information required for a decision and the information available for that decision [22]. Decision-makers coping with uncertainty are forced to make provisional decisions which are then adjusted as uncertainty-reducing information arrives as "news" [23]. While the physical act of production in manufacturing and construction inevitably involves materials flows, those materials flows are connected with the organisation within which they are housed and the markets which they are intended to serve through information flows. Thus, I submit, any theory of production needs to be a theory of both information and materials flows in the process – what has been called the *tectonic* approach to production [20].

6.4 The Unitary Concept of Value

The LC approach stresses the importance of the generation of value through the construction process – it is the third pillar of the TFV theory. More recent work on *revaluing construction* [45] has identified three dimensions to the value concept applicable to the construction process :

- The contribution that the asset created by the process makes to the client's business processes

- The contribution that the process makes to the supplier's business processes

- The contribution that the asset makes to society as a whole.

The fundamental issue is that these three dimensions of value exist in all projects, yet they are not necessarily aligned. A major issue in realising value in the constructed product is that they are typically seen as artefacts with a cost, rather than assets worthy of properly evaluated investment. One reason for this is that there is remarkably little research on how buildings add value for clients – the state of the art is reviewed in Spencer and Winch [46] and Macmillan [47]. In societal terms, a new road may add value for the government that constructs it and the travellers who use it, but can destroy value for those who live near it, or who value the natural environment that it destroyed. For this reason, stakeholder management [48] is a vital element in construction project management. Within the supply chain, the capture of greater value for one actor in the process – typically in the form of profits – can be at the expense of another. This is why a theory of how to align incentives within the project value system is a central part of construction project management theory [49] in order to avoid the cycle of adversarial relations and over-engineering [17 fig 6.5]. The members of the project value system are typically independent organisations which must make a profit from their participation in that system or die – a coalition of interests, rather than a team is the appropriate metaphor for the construction supply chain, even where there are formal joint venture arrangements in place as part of *integrated teams*. Thus value in the construction process and product is inherently contested, and we need to develop methods of ensuring that incentives are aligned both within the project coalition, and between the project coalition and external stakeholders. A unitary concept of value derived from quality management is, I submit, inadequate for such a task.

7. Conclusions

There is much agreement between the two positions articulated in this paper, although debate inevitably emphasises disagreement. Certainly, last planner is an important and distinctive innovation in construction project planning, and the other techniques adopted for the LPDS are appropriate. It was suggested that additional techniques such as critical chain could also be adopted with benefit. It was also suggested that the existing project management toolbox still has much to offer – arguably what is at issue is how it should be used, not whether it should be used. The TFV theory is based on a refreshing reading of the production and operations management literature, and moves the debate on the organisation of production in construction forward considerably. It was argued, however that it would benefit from further development because of the strong focus on the physical processing of materials as an engineering problem; the absence of a concept of organisation in the analysis; the lack of any analysis of the implications of risk and uncertainty; and its unitary concept of *value*. We need theories of production, because without them we cannot determine which tools and methods it is appropriate to adopt from manufacturing industry, and which are inappropriate due to the site specific nature of construction [5, 34], but such theories need to be based in the social science of organisation [50] as much as in the techniques derived from operations research which form the principal foundations of LC [3, 4].

The theory underlying MCP has been elaborated elsewhere [19, 20, 34, 49]. The aim of this paper has been to engage in a debate with the advocates of lean construction as we jointly and severally attempt to develop a theory of construction as production by projects. Arguably, the most important thing that construction can learn from manufacturing production is something that it gave away in the first place – the fundamental role of project forms of organisation and their effective management in the production of unique, site-specific products under time constraints.

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Adopting Partnering in Sweden: A Critical Perspective

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Abstract

The past decade has seen several governmental initiatives in the UK aimed at improving the performance of the construction sector. These initiatives have resulted in the establishment of various bodies promoting best practice and the release of highly influential reports, which, despite being heavily criticised, have had a marked influence on industry discourse and research agenda alike. These reports are increasingly influencing not only the UK and other Anglo-Saxon countries but also countries with disparate regulatory systems, customs and construction practices. The research presented here explores the influence on the Swedish construction sector of the construction best practice discourse emanating from the UK. In particular it investigates how the discourse of partnering has invaded the Swedish market. Conclusions are drawn based on an extensive compilation of partnering related articles in Swedish press and the preliminary findings from an interview survey targeting construction practitioners. The paper concludes by highlighting ambiguities surrounding the purported improvements and the experienced realities on projects and questions are raised concerning the motivations and possible hidden agendas of those promoting partnering in Sweden.

Keywords: Best practice, partnering, change, resonance

1. Introduction

Recent years have seen increased attention and resources given to construction reform initiatives in a host of countries. Exactly how these initiatives have played out is quite obviously dependent on the specific country in question, but they all have in common their call for a change in a sector that is believed not to be performing. The UK could be singled out as a country with a long history of government initiatives aimed at evaluating and improving the construction sector. Over the last decade several policy makers and their respective organisations have been instrumental in highlighting the problems facing the sector and recommending the changes necessary to alleviate such problems. A variety of initiatives have been undertaken resulting in the publication of several highly influential reports (cf. [1][2][3]). These reports have, in turn, been poured over by numerous construction management researchers and used as pivotal arguments for research projects seeking government funding.

This paper sets out to explore the influence and diffusion of UK change initiatives, the movement for change, onto the Swedish market and its effect on policy makers and industrialists. It does so from the viewpoint of contextual understanding. In particular the paper sets out to illuminate the questions of why the some actors are keen on promoting and implementing partnering and why attempts might fail. The first part of the paper explores and sketches out the discourse for change in the UK construction industry that is finding a purchase within the discourse of change in other countries. The second part of the paper challenges the assumptions underpinning this discourse of change and highlights some fundamental issues that are missing in the adoption of this discourse in other countries. The third part of the paper explores a specific example of the best practice discourse related to partnering in the context of the Swedish construction sector. Support for the arguments presented are taken from numerous discussions and interviews with representatives, both junior and senior, from a variety of Swedish construction companies including architects, clients, contractors, designers and technical consultants. The final part of the paper presents preliminary conclusions to this largely desk based study and a framework for further research.

2. Discourse of Change in the UK

The UK has a long history of reports bemoaning the performance level of the construction industry. Indeed, it has for the last 60 years been the subject of a steady stream of governmental reports. Since 1975 these have been conducted with an interval of between 3 and 5 years [4]. Whilst these reviews have been influenced by contemporary issues of concern, Murray and Langford conclude that they have more often than not uncovered similar industry ills. It is, indeed, evident that the reviews share similar messages regarding the sectors performance and only show subtle differences in the reasons that are given thereof. The rhetoric might have changed and new buzzwords have been introduced, but in essence the underlying issues have been the same. Aspirations of integration, teamwork, trust, partnering, standardisation, value for money pervade and the need for alternative managerial practice within the sector to facilitate these aspirations is a common theme - especially in contemporary reports. Likewise, the presented challenges or barriers to these aspirations are remarkably similar: resistance to change; undesirable culture; and fragmentation. However, a change in governmental policy can be detected as of the Latham-report in 1994. The contemporary movement for change has taken a more hands-on approach by recommending and introducing particular methods of delivery that are believed to facilitate their aspirations of change in the sector. The influence of clients during this period is worth noting as the ongoing commitment to regularly procure from the sector by particular clients is clearly reflected in the change agenda. This dominant position of clients is not serendipitous; Murray [5], for example, points out that the CTF deliberately excluded contractors. Despite a more balanced representation within the ‘Movement for Innovation’ and ‘Construction Best Practice Programme’ client dominance still prevails. The contemporary movement for change is captured articulated and rooted within publications and initiatives from 1994 onwards:

- the Latham report [1];
- the CTF’s widely cited *Rethinking Construction* report [2];
- its sequel the *Accelerating Change* report [3];
- the *Better Public Buildings* report [6];
- the *Clients’ Charter Handbook* [7];
- the *Modernising Construction* report [8] and;
- the establishment of Constructing Excellence

Even though it is not without its critics [9,10,11,12] the movement for change has a strong hold over the industry discourse and is largely responsible for the introduction of management initiatives throughout the construction sector and has been given considerable support from Government.

The actual change sought after is promoted through identification, implementation, monitoring and measuring of ‘best practice’. The kind of best practice sought after is, in turn, largely designed to address and revisit the aspirations of integration, teamwork, trust, partnering, standardisation and value for money, mentioned above. The identification of best practice, which is largely achieved through ‘learning from other sectors’ and benchmarking, is, therefore, driven and biased by these aspirations.

Partnering serves as a prime example of best practice imported into the construction domain. In a fashion partnering is seen as a remedy for several of the performance deficiencies that have been around for the last 50 years and claims are commonly made along the lines of performance benefits in terms of cost, time, quality and a range of other criteria. The concept has, thus, found its place within the contemporary movement for change and has been highlighted in a number of reports (e.g. [1, 13, 14, 15, 16, 17, 18, 19]).

3. Discourse of Change in Sweden

At times the Swedish construction sector is praised for its international competitiveness, leading architectural design and high overall quality; a common description in international benchmarking studies (cf. [20]). Yet, more and more often the sector is accused of being conservative and adversarial to clients and blamed in the national press for all sorts of malpractice and more or less dishonest behaviour, e.g. technical faults, poor safety and ignorance of environmental issues. The last five years has seen issues such as alleged cartels in asphalt and material supplies, malpractice on high profile projects and perceived unreasonably high costs of construction being scrutinised in the mass media. This has lead to an increased awareness amongst members of the public of failings in construction projects. In particular, the exposure of malpractice and faults on a series of high profile projects during the first two years of the century placed the debate in the national newspapers.

Governmental initiatives have been undertaken to investigate the underlying reasons for the sector's perceived failings. Examples include the forming of the Building Cost Delegation [*Byggkostnadsdelegationen*], under the auspice of the Ministry for Industry, Employment and Education in 1996; and the Building Commission [*Byggkommissionen*], within the Ministry of Sustainable Development in 2002. The specific objective of the Building Cost Delegation was to determine the underlying reasons for the high costs of construction. Whilst the objective of the Building Commission was to propose measures that would foster competition and prevent competition hampering behaviour, use of illegal labourers and the forming of cartels. At the same time various interest organisations (cf. [21]), individual firms (cf. [22,23]) and industry commentators (cf. [24]) also started to make their voices heard, providing their own set of causes, explanations and solutions.

Although the messages that have been conveyed vary slightly and the underlying motives most probably differ, most of the arguments and recommendations put forward, from the public and private side, have in common a reliance on the 'movement for change' discourse emanating from the UK. In the case of the government initiatives the Building Cost Delegation's final report [25] was influenced by the Latham Report [26] and the work of the Building Commission was heavily influenced by the Egan report and the Rethinking Construction agenda [27]. From the private sector side the arguments have been supported on the perceived benefits of initiatives such as Rethinking Construction (e.g. [28]), but more often on the broad recognition of consistently higher performance in other sectors – e.g. automobile sector – and pockets of higher project performance within the construction sector itself, provided in the movement for change discourse. In particular, the concept of the transferability of 'best practice', in the form of partnering, is central to their recommended content of change.

Partnering has, indeed, been placed high on the agenda amongst those looking for a change within the sector. Whilst it could be argued that this development has been industry led, in particular by contractors, see for example [22,29], it has also been the subject to a relatively high degree of attention within the Swedish construction management research community (e.g. [30,31,32,33,34]). Several powerful arguments in favour of partnering have been put forward and the advocates present strong cases for its use. Yet, the concepts differ and could be considered to be imprecise, inclusive and subject to continuous redefinition. It is difficult at times to distinguish between the promoted version of partnering as a distinctive practice or as managerial rhetoric. Indeed, confusion continues to prevail at a variety of levels, as for example, in distinguishing between partnering and collaborative working.

4. A Critical Perspective on the Discourse of Change

Failure to understand and relate initiatives to context is understood to be the reason why many contemporary change programmes consistently fail to deliver [34]. Following this line of reasoning it is argued here that in seeking to change managerial practice it is essential that context is recognised as an influential aspect of any analysis of managerial practice. Indeed, from a change management perspective it is surely common sense to fully understand why and how organisations and individuals legitimise current practice before prescribing a need for change and how such change might be implemented. This point is not lost on theorists within organisation studies who have recently explored the use of theories such as structuration [35], institutionalism [36], and evolutionary economics [37] that highlight the importance of various aspects of context.

Historically, industry commentators as far back as Higgin and Jessop [38] have, indeed, made attempts to conceptualise and understand context when addressing such issues as interdependency, communication and uncertainty in the construction sector. However, almost paradoxically, the contemporary change agenda in the UK construction sector appears to be narrowly focused on the need to adopt alternative managerial practice, and, hence, tends to underplay or ignore the importance of context in their analyses (cf. [10,39,40]).

Underplaying or ignoring context could be equalled to assuming that the particular best practice in question, be it partnering or something else, is similarly interpreted by all individuals involved in its implementation. Such assumptions fail to take into consideration the infinite number of reasons why employees and managers within an organisation may object or even obstruct management initiatives recommending alternative practice. Furthermore, a key issue that is likely to be missed is the concept of ‘resonance’ [41] whereby legitimacy is given to creative ideas if, and only if, they resonate with the concerns of individuals (or groups of individuals). Hence, whilst rhetoric based on common sense such as team working is difficult to refute, what is easy in principle is not automatically easy to achieve in practice, and might not even be advisable. Could it not be possible that perceived barriers to change in the sector such as adversarial contractual relationships and opportunistic behaviour are legitimate actions of practitioners embedded in the context of the construction sector? If so, simplistic calls for change associated with collaborative working will continually fail to resonate with practitioners. Therefore, what is questioned here is not the existence of potential benefits of the cornerstones of partnering, such as trust and mutual understanding. Rather it is its legitimacy in regards to existing practice and context.

Further support could be found in the widely spread criticisms of universalistic assumptions regarding the application and implementation of best practice. It has, for example, been argued that best practice has to be coupled with the need to understand the circumstances within which it is used, when it is used and why (e.g. [42,43,44]). Essentially the above authors argue for a move away from imitation on the basis of simplistic cause and effect to a position that concedes learning to be drawn from understanding and challenging ‘cause and effect’ in its context.

Effectively it is argued that notions of learning and knowledge sharing have much to contribute towards achieving better organisational performance and understanding the link between practice and performance.

5. Partnering in Context: Discussion

There are notable papers that broadly criticise the movement for change in the UK on the basis of an unreflective allegiance to instrumental management techniques [9,11,45,46]. Indeed, Green [45] rather gratuitously used the phrase ‘technocratic elite’ as a broad descriptor for those responsible for promoting change. It would be naive to think that vested interests are the only forces at work. But it would be equally naive to argue that the promoters of partnering are motivated solely by altruism.

The core argument presented in this paper is that practice is not enacted within a vacuum. In essence, analysis of change, recommendations for change and implementation of change, must be sensitive to the dynamic relationship between context and practice. Failure to do so run the risk of making any associated change initiatives partly or wholly irrelevant. It is contended that such thinking and sensitivity is under developed within the promotion of methods such as partnering. To further put this into perspective it is worth noting that that there historically has been a clear resistance amongst Swedish clients to change the traditional allocation of responsibilities and ways of working [26]. Thus, whilst it in the UK could be argued to be the client side that has been more active in pushing for a change, in Sweden this has not been the case, as clients, in general, have been sceptical to the idea. Also, contractual relations are thought to be less antagonistic in Sweden than in the UK and US. In their review of dispute resolution and conflict management practice in Sweden Bröchner et al. [47] found that very few conflicts are settled by formal dispute resolution mechanisms. Furthermore, competition is to a certain degree limited on the Swedish construction market. A long term development of mergers and acquisitions has led to an industry structure of three dominant construction contractors, a handful of contractors specialising in housing and an abundance of very small contractors. A similar development has also taken place in the area of consultants and material suppliers. This limitation in competition could in itself be an incentive for long term buyer-seller relationships [26]. It is notable that although the Building Cost Delegation arguably sparked the debate it did not identify conflict as an important topic for improving the sector.

Context is, however, by no means a simplistic or static entity since it concerns a raft of highly complex, dynamic and influential factors. Organisations themselves are highly complex, dynamic and influential contexts. Practice, in turn, is embedded within and mediated by context. This relationship is symbiotic as context is also shaped and reinforced by practice. Attempts to change context can, therefore, be as influential and important as attempts to change practice when challenging the status quo. In essence, context and practice should be viewed as different aspects of the same reality [48] and the temptation to treat them as separate units of analysis should be resisted. Research is needed that engages with this reality by similarly engaging with practitioners within the construction sector to understand the legitimacy of their actions and their reactions to the content of change.

The preliminary findings from the interviews support the above argument. The impression given by the interviewees is that they have difficulties in seeing the difference between what is being forced upon them in the form of partnering agreements and guidelines and what they consider to be common practice. Collaboration is considered to be common place on ‘traditional’ projects though most agree that it is informal and perhaps slightly over reliant on personal relations. Compromises are common and the degree of mutual understanding is considered to be high. Problems arise if personnel do not get along, but as one of the interviewees pointed out: ‘it might be in the agreement [on a partnering project] to change the people in the team, but that is what we do on traditional projects’. Thus, the concept of partnering, as imported and adapted from the UK context into the Swedish discourse of change, is failing to fully resonate with those who are charged with the day-to-day work.

The potential value of change is found in its resonance and applicability to the surrounding context and it is this context itself that determines both the applicability of and opportunity for change. It is therefore clear that for any proposed change to find legitimacy it has to resonate with current or contemporary concerns and issues [41] in the context that they are played out. Several of the interviewees did, indeed, struggle with this. One interviewee phrased it: ‘*partnering to me is when you open up a new shoe shop with a partner, sharing risks and rewards. That is partnering*’. It seems that very few of the people involved in the actual work see it as if something new is taking place. The feeling is that of superimposing a new word to describe something that has been around for decades. This was also the view of a project manager with experience from a couple of partnering projects: ‘*I’ve always been positive to partnering. Not the word partnering, but long term collaboration and collaborative working… I don’t like partnering. I don’t like the debate on partnering. There is nothing substantial behind it*’. The company he represents has been working closely with a number of clients for a long time and at present none of their work in the particular region has been won through competitive tendering. Furthermore, it was a common impression amongst the interviewees that the promotion of partnering as a new and tangible phenomenon was the result of a rather aggressive marketing drive by one of the large contractors and that others had chosen to follow suite. “*It is that large contractor that is pushing*”. Even so consensus was that companies could not afford not to officially support partnering: “*It is politically and commercially correct to like partnering*”. Again this points towards that the concept of partnering, as promoted and implemented on the Swedish construction market, is failing to find resonance amongst those charged with the day-to-day work.

6. Conclusions

It is unclear why the UK movement for change has failed to engage in an exercise to understand the legitimacy of managerial practice in the construction sector over repeated attempts to describe the sector as ‘ill’ and in need of change. The amount of attention that it is getting in other countries, such as Sweden, is therefore puzzling. The recognition of context and the pivotal role it plays in shaping contemporary managerial practice should be of prime concern to policy makers, practitioners and academics engaged in advocating change within the sector.

This paper does not contend that the Swedish construction sector is faultless and not in need of change. Neither is it contended that partnering is necessarily a bad thing, in fact the main criticism of partnering is the vagueness of the term. What is contended is that the promotion and adoption of partnering in Sweden is based on misconceptions of the concept its origins and context. There seems to be a broad recognition of the need for change within the sector. However, it is not entirely clear if the change that the sector wants is in the form of how it is perceived by the public or in how business is done. Whilst the latter quite obviously affects the former it is by no means a prerequisite.

The first phases of the research have shown that there is reason to be restrictive in taking the debate on partnering in Sweden at face value. The importance of context is as of yet under explored and does not seem to be taken into consideration amongst those advocating partnering; be it the companies that are leading the way or the posse of industry commentators and at times academics that are backing them. As could be expected there is a resistance amongst the workforce who cannot understand what all the fuss is about. The concept has, as of yet, failed to find resonance and individuals fail to see the difference in working and, furthermore, do not understand how a contract/agreement specifying what they consider to be ‘practice as usual’ can lead to the improvements they read about in the papers or are told about at various seminars etc.

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An Experimental Study of the Use of Critical Chain Programming in the Construction of Social Housing Projects

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Abstract

This study sought to determine whether critical change project management did improve project completion times and/or completion certainty. The study used social housing projects as the basis for the study and adopted an experimental approach. Three experimental projects; all social housing schemes had their construction managed using the critical chain technique. To provide control projects, three comparable projects were constructed and managed without the use of critical chain. An additional number of comparable projects that had already been built without the use of critical chain, were analysed post-completion to increase the available data of control projects.

The results were presented separately for dwellings and for flats. The results for flats revealed that the experimental project using critical chain did perform better than the control projects when measured against a number of criteria, notably, a) time per dwelling, b) value produced per working day and c) area constructed per working day. The results for flats were mixed and can only be regarded as inconclusive at this time, although there is data to show improved performance in a number of criteria. All the control projects were completed within their contracted completion date. Further analysis of the data is being undertaken to increase the certainty of the results.

Keywords: Critical chain, planning, performance, housing

1. Introduction

Critical chain is one of a number of recent developments in the techniques of project programming and management that have come about because of perceived deficiencies in more traditional programming and scheduling tools; most notably their failure to control time overruns during the construction phase of the work. The critical chain technique purports to provide project managers with the ability to better manage and control time overruns.

This paper reports the initial results of a study to determine the effect of using the Critical Chain technique on the construction of a number of similar social housing projects. The study specifically sought to determine if a time difference exists between projects managed using critical chain and those that were not and if so to quantify the difference. The hypothesis stated that; critical chain would improve the construction time of projects. In addition to determining the time performance of critical chain, other subjective observations were made with the aim of discovering any other implications that derive from employing critical chain, together with any anomalies produced by the use of the technique. Subjective issues such as, the ease and extent that the technique is adopted by site staff, the effect of using the technique on the management of the projects, and any developments that lead from the application of the technique.

1.1 Critical Chain

The principles underlying the critical chain technique of project programming derive from the application of certain aspects of the Theory of Constraints to a project environment. [1]. Critical chain uses a project programme that has been planned and programmed using a precedence or CPM network, the key areas of difference between critical chain and these traditional forms of project management using networks and critical paths, is in the way that Critical chain handles, a) activity durations and b) the float time for each activity.

Critical chain is based upon the premise that in every activity duration, there is by default, a certain amount of spare time or 'buffer' included in the duration. Even where the activity is critical, a small but identifiable amount of spare time exists and that if all these spare times can be collected together into a 'buffer', they can be used usefully to keep the project on schedule. Critical chain introduces a range of specific terminology as part of its system, 'buffers' describe float or spare time, an 'activity buffer' occurs within each individual activity. It is these individual 'activity buffers' that the critical chain technique identifies as being unrecognised and unused, and which in other programming systems become wasted. Critical chain collects these individual 'activity buffers' and places them in a 'strategic project buffer', which sits at the end of the project and is used to the benefit the whole project.

Having established a strategic buffer, critical chain uses a system called 'buffer management' to monitor and control the progress of the project. This records the extent and rate at which the strategic buffer is being consumed by any delays that may be occurring within the project. A traffic light system provides a quick way of assessing how critical the rate of buffer usage is and indicates to management where action is required to rectify the situation. This provides a means of prioritising management action to deal with the causes of the delays. In essence it provides a continuous indicator of buffer usage and a mechanism for making decisions on whether or not to instigate recovery actions.

The critical chain approach requires the reduction of task durations from those estimated with a high probability of delivery to ones that were 'challenging but achievable', this approximately equates to reducing task durations with a probability of 80% certainty of completion to 50% certainty of completion. The 'Prochain' project management software identifies the critical chain through the project, calculates the strategic project buffer and the 'feeding buffers', that are required for the application of the 'buffer management' project control process.

2. Methodology

The study adopted an experimental approach. Three experimental projects, all social housing schemes, were selected and their construction managed using the critical chain technique. To provide control projects, three comparable projects were constructed and managed without the use of critical chain. To establish as large a control or baseline data set as possible, an additional number comparable projects were selected that had already been built without the use of critical chain, these were analysed post-completion to increase the available base-data of projects constructed without the use of critical chain.

From the outset, the biggest issue with respect to the design of the experiment and the collection of data was that of comparability. Despite being selected to be as similar in size, character and construction as possible, none of the projects used in the study was exactly the same as any other, there were always a number of differences that would, or could, be sufficiently significant to alter the comparability of the projects under study. These variables were identified as site layout and size, mix of dwellings, location, site management team, client, time of construction, labour usage, plant usage,

Site layout was invariably different for all the projects included in the study, however this did not present as great a variable as at first envisaged. By only including data from comparable building types, such as low rise dwellings and flats in a single block, significant errors were eliminated. The second factor that smoothed-out the difference in this variable was density. The sites studied were developed to a similar building density and were sufficiently comparable within type to eliminate without adjustment from the comparison.

The extent of external works does present a significant difference between projects, depending upon the site itself plus the extent of excavation, drainage, roads and paths, etc. External works seldom featured as a critical activity on any of the projects, except occasionally and very briefly on some of the projects. The absence of any major enabling works prior to the commencement of construction of any of the projects, together with their non-critical character, indicates that the time taken for these works does not significantly contribute to the overall time for each project and can therefore be ignored as a variable. They do however affect the results for value erned per working day.

The size and mix of dwellings within each project also fell within acceptable limits of comparability, as the majority of the projects were for comparable clients, namely social housing providers, whose specified requirements for size, mix and quality were generally equivalent if not exactly the same. For the purposes of analysis, variability in the size, mix and quality of the dwellings were initially ignored, however this is now subject to detailed review. Data that was time sensitive, such as costs, was updated using tender price indices. All the projects were in the same regional location, which eliminated regional differences in cost, construction, weather, etc. as variables between the projects.

Progress and performance data was collected for the experimental and control projects on a weekly basis, together with a range of other data relating to project specific factors that might distort the performance of each project, such as weather, breakdowns, labour shortages and any incidents that materially affected progress.

2.1 Cross-contamination

The critical chain technique was introduced to the site managers of the experimental projects through a series of workshops, these consisted of two day training programmes, which explored the principles behind Critical Chain project management and how it could be applied to the construction projects. The need then arose to prevent the managers who would be using critical chain on the experimental projects from influencing the managers of the control projects who would not. Leaking of ideas from the ‘new’ system to the control projects would, if substantial, ruin the validity of the study. In the normal day to day operation of the firm, contact between site managers was minimal, however there were collective events at which the managers interacted. Managers on the training courses agreed not to discuss the critical chain technique or any related aspects with colleagues until the experiment has ended. Similarly, contract managers with responsibility across both types of project also undertook not to discuss any aspects of the experimental or control projects with the respective site managers. Finally in order to ensure that no cross-contamination had affected the management of control projects, a number of control projects that had already been completed prior to the experiment, were added to the analysis.

A number of events had a significant effect on construction progress that were specific to each project, events such as weather, stoppages and any incident/event that caused lost production time. These were deducted from the total working days to complete the project to produce a net figure.

3. Results and Analysis

The results have been analysed and presented into two comparable sets of data, those for traditional dwellings and those for flats (apartments). Analysis of the data for each project has not been adjusted to take into account the different sizes of each respective project, apart from showing the total construction time in working days, the data has been related to criteria that are not so susceptible to overall size of the project, such as working days per dwelling, floor area per working day and value per working day.

3.1 Traditional Dwellings

Table 1: Data for traditional dwellings

	Kings Hill 3	Hobbs Lane	Kings Hill 1	Kings Hill 2	Herne Road	Kings Hill 4
No. of dwellings	20	10	32	15	23	26
Constructed building area	1732.5	***900***	1549	1450	2006	1939
Area per dwelling	86.63	90	48.41	96.67	87.22	74.58
Cost £ (000's)	1850	930	1190	1230	1972	***2405***
Construction time [wkg.days]	214.5	215.5	260.5	206	374	297
Working days per dwelling	10.73	21.55	8.14	13.73	16.26	11.42
Area constructed per working day	8.08	4.18	5.95	7.04	5.36	6.53
Value/working day (000's)	8.62	4.32	4.57	5.97	5.27	8.10

An initial analysis of the results indicates that the critical chain technique did improve the performance of the projects in terms of time. The experimental project [Kings Hill 3] achieved a faster construction time than all the control projects with the exception of one [Kings Hill 1], when measured in terms of working days per dwelling. This discrepancy may be the result of the smaller unit size constructed on the Kings Hill 1 project, a point still to be confirmed.

Table 2: Working days per dwelling

Kings Hill 3	Hobbs Lane	Kings Hill 1	Kings Hill 2	Herne Road	Kings Hill 4
10.73	21.55	8.14	13.73	16.26	11.42

The result for Hobbs Lane [21.55] is significantly different to the results on the other projects, which raises the question of comparability, because of this and other anomalies in the results the project will be subject to further analysis to determine the validity of the project and data derived there from.

Table 3: Area constructed (M2) per working day

Kings Hill 3	Hobbs Lane	Kings Hill 1	Kings Hill 2	Herne Road	Kings Hill 4
8.08	***4.08***	5.95	7.04	5.36	6.53

Analysis of the results on the basis of the area constructed per working day shows the experimental project to produce at a rate of 8.08 m2/day that is greater than the control projects, which all performed below this figure. Similar results are produced when performance is measured in terms of the value produced per working day, the experimental project out performs the control projects (Table 4)

Table 4: Value (£,000's) per working day

Kings Hill 3	Hobbs Lane	Kings Hill 1	Kings Hill 2	Herne Road	Kings Hill 4
8.62	4.32	4.57	5.97	5.27	***8.10***

The time taken to construct any of the projects could have been distorted by introducing exceptionally different construction methods, either throughout or for part of the project to overcome problems that were encountered during construction. Thus far the analysis of the projects in the study has not revealed any unusual construction methods that would be sufficient to influence the results. Labour returns from the main contractor and all their sub-contractors were collected and analysed for every project. These were analysed in relation to the programme and the progress to determine whether sufficient numbers of workers had been flooded into a project to distort the construction time. The analysis revealed no peaks in labour supply that were greater than those that would be expected in the normal operation of sub-contractors working on multiple projects simultaneously. The analysis to date of the labour used per dwelling and value earned shows an acceptable level of consistency across all the projects.

3.2 Flats

Table 5: Data for flats (apartments)

	Prince Regent Lane	Harrow Road	Somertrees	Lord Warden Avenue	Burnt Ash Hill
No. of dwellings	50	46	40	10	13
Constructed building area	2736	3212	3759	659	***1200***
Area per dwelling	54.72	69.83	93.98	65.90	92.31
Cost £1000's	2900	3700	3600	720	1200
Construction time [working days]	302	393	331	182.25	240.5
Working days/dwelling	6.04	8.54	8.28	18.23	18.50
Area constructed per working day	9.06	8.17	11.36	3.62	4.99
Value/working day	9.60	9.41	10.88	3.95	4.99

The results for the performance of the experimental projects for flats, namely Prince Regent Lane and Burnt Ash Hill, are inconsistent with respect to each other and in relation to the control projects used in the experiment. Initial analysis of the performance achieved by the various projects shows that the experimental projects did not out-perform the control projects. Prince Regent Lane was faster in terms of working days per dwelling [6.04], but was lower than other projects when measured in terms of area constructed per working day [9.06] Somertrees [11.37].

Similarly the criteria of value per working day showed Somertrees [10.88] to be better than either of the experimental projects. The second experimental project, Burnt Ash Hill, exhibited significant differences in performance with the control projects, except Lord Warden Avenue and Prince Regent Lane. The analysis has confirmed concerns regarding the comparability of some of the projects, which will now be subsequently re-analysed. It is suspected that underlying these divergences may be the size of project with regard to number of dwellings plus the amount of ancillary facilities and space that forms part of these projects. Re-analysing the experimental projects in comparison with the control projects of a similar size provides a different perspective. These are shown in Tables 6 and 7.

Table 6: Data for Prince Regent Lane and comparable projects

	Prince Regent Lane	Harrow Road	Somertrees
No. of dwellings	50	46	40
Constructed building area	2736	3212	3759
Area per dwelling	54.72	69.83	93.98
Cost £1000's	2900	3700	3600
Construction time [working days]	302	393	331
Working days/dwelling	6.04	8.54	8.28
Area constructed per working day	9.06	8.17	11.36
Value/working day	9.60	9.41	10.88

Analyses of these results show a closer fit in terms of number of dwellings and project size. The time performance for the experimental and the control projects are more comparable, the time per dwelling shows the experimental project to be faster, 6.04 working days per dwelling. However in terms of area constructed per working day and the value produced per working day, the experimental project was outperformed by one of the control projects.

Table 7: Burnt Ash Hill and comparable control project data

	Burnt Ash Hill	Lord Warden Avenue
No. of dwellings	13	10
Constructed building area	***1200***	659
Area per dwelling	92.31	65.90
Cost £1000's	1200	720
Construction time [working days]	240.5	182.25
Working days/dwelling	18.50	18.23
Area constructed per working day	***4.99***	3.62
Value/working day	4.99	3.95

There are problems and deficiencies with these data sets and projects that will require further analysis to resolve. Not least the limited number of projects may invalidate the results and further data collection may be necessary to resolve the performance issues.

4. Conclusions

All three experimental projects were completed ahead of, or on their contracted time, in contrast to similar previous jobs that had consistently finished late. The results produced by the study indicate that critical chain does improve the performance of constructing the dwellings. It could be argued that this was more to do with the 'Hawthorne effect' surrounding the new technique, rather than a result of using the critical chain technique itself. This could indeed be the case, but the facts of the matter are that the projects did achieve their contract completion dates whilst operating critical chain and there is data to support this deduction.

The anecdotal evidence coming from the study suggest that critical chain has had some success in effecting cultural change amongst the site managers and contract managers involved. They acknowledge that critical chain has obliged them to properly plan the construction programme in order to provide the base for the application of critical chain. Whether this should have been done in any case is not the point; it was not. The fact is that it is now being done and should improve the management of future projects irrespective of whether critical chain is applied or not and must be considered a positive development. The operation of critical chain has also forced site and contract managers to focus on important issues and to prioritise their efforts towards important issues.

All these points suggest that critical chain has achieved a measure of management development regardless of its original intended method. It could also be claimed that the results achieved using critical chain could potentially be achieved using a number of other techniques and systems of management. This could be true, but critical chain has actually achieved these results in these instances. All three projects performed better than previous similar projects and on a number of criteria, better than the control projects. With regard to the performance of critical chain on the construction of flats, the results are far from certain and must be regarded as inconclusive. Further larger scale studies will be needed for both dwellings and flats to determine the specific effects of critical chain.

Acknowledgments

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Law as a Critical Tool in Applied Construction Management Research

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Abstract

The paper explores the interdisciplinary nature of the construction management research and considers the contribution that the law subject discipline can make within it. It distinguishes academic legal research from empirical research and explains the distinction between doctrinal and socio-legal research. It argues that construction-related legal research is necessary to address areas which are beyond the scope of empirical investigations, and which have also been neglected by mainstream legal scholarship. Using examples it suggests that this has a particular role to play in challenging areas of practice which are not in conformity with legal requirements.

Keywords: Construction management, epistemology, methodology, inter-disciplinarity, law

1. Introduction

This paper explores the role of academic legal research within the construction management field. It describes the nature of this form of enquiry and contrasts it with more familiar styles of investigation within construction management research. It suggests that academic legal research has been a largely neglected activity within our field and that this has been to the detriment of the construction industry. It argues that this style of research has a particular role to play in the context of certain problems within the industry that are incapable of resolution by empirical or theoretical scientific enquiry.

It begins its analysis with an attempt to understand the nature of construction management research by placing it in its broader disciplinary context. It then discusses the different types of academic legal research that might be employed within the field and explores the value of these approaches to the construction industry. Finally, it introduces two different examples of construction-related academic legal research and discusses how these are providing benefits for the industry.

2. The Disciplinary Nature of Construction Management Research

Like all other academic fields, construction management is an activity that defines itself by reference to its particular subject of study. In other words it lays claim to a particular portion of the wider field of academic knowledge to justify its place in the academy. This raises questions about the characteristics of its particular portion of academic knowledge, and about the boundaries between it and those of its nearest academic neighbours. These can best be answered by reference to the Biglan [1] disciplinary model which is now widely accepted as a basis for cross disciplinary comparisons. This groups the various fields of academic study within a matrix, broadly according to a two-fold art/science and pure/applied categorisation. Based on work by Biglan [1] and Kolb, [2] the position of individual academic disciplines can be plotted on the matrix as illustrated by Figure 1.

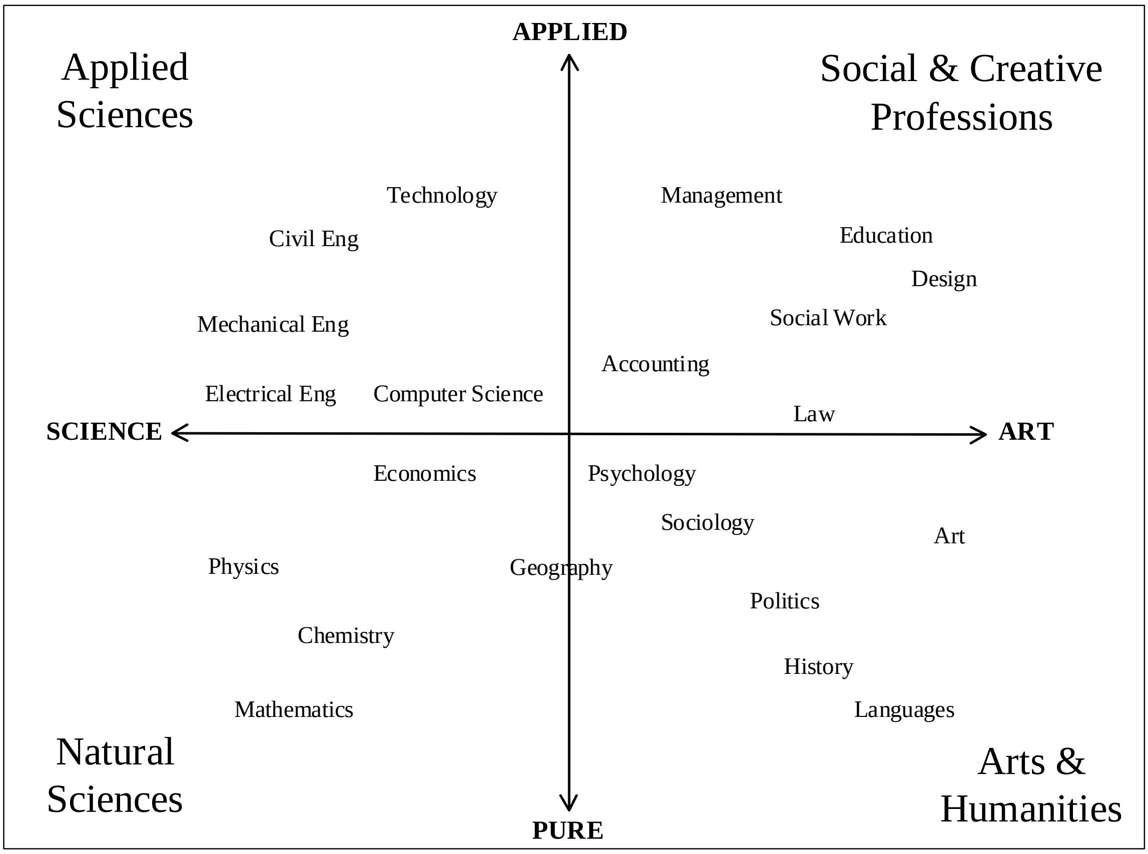

Figure 1: Disciplinary Model (after Biglan)

If the construction management discipline is considered in the context of this model the diverse nature of the field becomes apparent. There is a wide level of agreement within the field that, at a cognitive level, it is actually a combination of traditional sub-disciplines rather than a homogeneous discipline in its own right. These may be described in a variety of ways but, for the purposes of this paper, they are taken to be: Management, Economics, Law, Technology and Design.

The location of the various sub-disciplines within the matrix demonstrates the predominantly applied nature of construction management's academic territory. It also highlights its diversity in spanning academic practices across virtually the whole spectrum of the arts and sciences. This is significant in the current context as these different academic practices (or sub-disciplines) are naturally involved in the production of very different types of knowledge. They must therefore embrace different epistemologies when assessing the validity of the knowledge with which they engage, and employ different and appropriate methodologies in its production.

It is submitted that the approach of the construction management academic community should therefore vary, according to the nature of the problem being confronted. It should have the collective capability to provide solutions to the industry across the whole range of its sub-disciplines, but can only do so effectively if it fully understands the epistemologies and methodologies which are appropriate for different styles of investigation.

3. The Nature of Academic Legal Research

3.1 Epistemological and Methodological Approaches

The epistemologies and methodologies employed in academic legal research are rarely made explicit. Nevertheless, based on a model proposed by Arthurs [3], it is possible to construct a matrix of legal research styles which broadly follows the generic disciplinary model described above (Figure 2). Once again, a distinction exists between pure and applied research and this is again represented by the vertical axis on the matrix. However, the more interesting distinction is that between doctrinal and socio-legal research which is represented by the horizontal axis.

3.2 Legal Doctrines

Doctrinal research is concerned with the formulation of legal doctrines through the analysis of legal rules. Within the common law jurisdictions legal rules are to be found within statutes and cases (the sources of law) but it is important to appreciate that they cannot, in themselves, provide a complete statement of the law in any given situation. This can only be ascertained by applying the relevant legal rules to the particular facts of the situation under consideration.

Deciding on which rules to apply in a particular situation is made easier by the existence of legal doctrines (for example, the doctrine of consideration within the law of contract). These are systematic formulations of the law in particular contexts. They clarify ambiguities within rules, place them in a logical and coherent structure and describe their relationship to other rules.

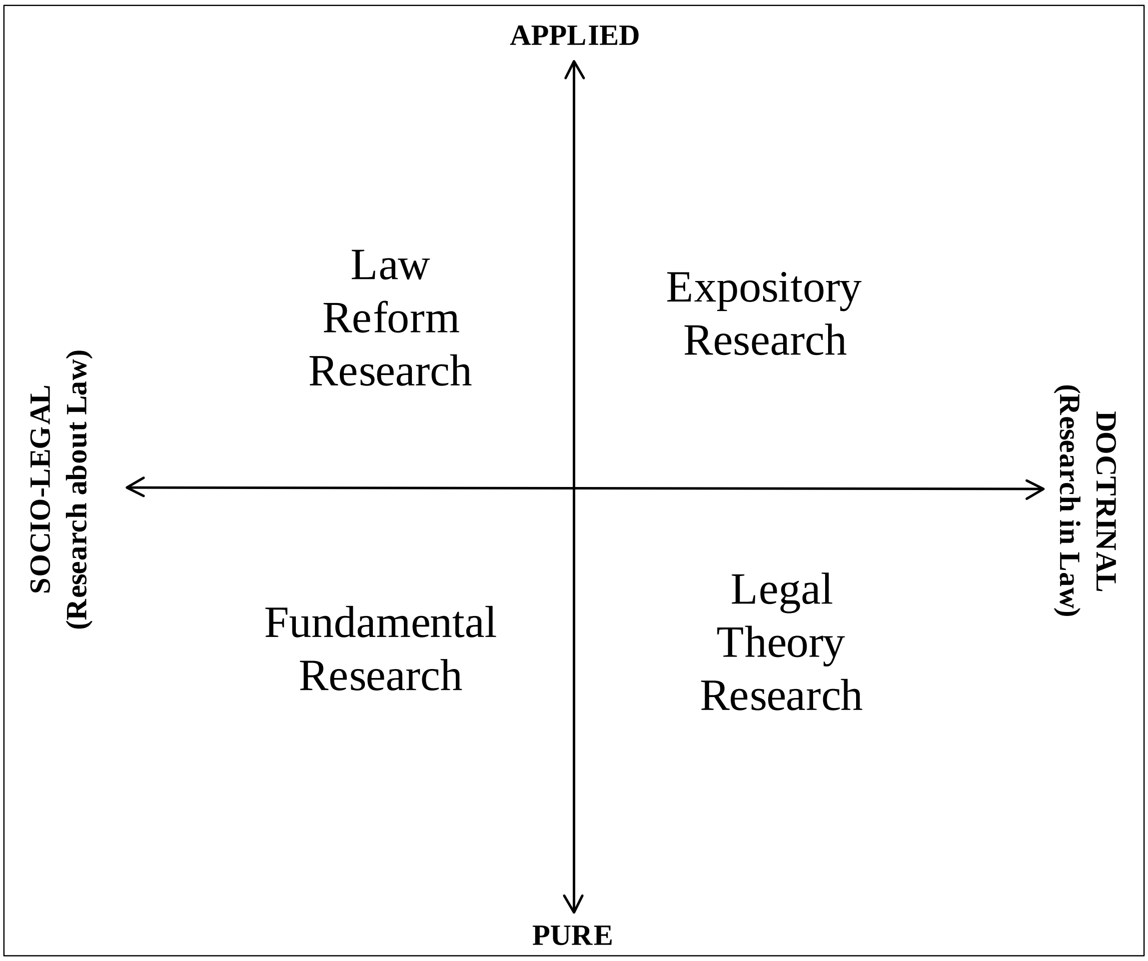

Figure 2: Legal Research Styles (after Arthurs)

3.3 Doctrinal Legal Research

Doctrinal legal research is concerned with the discovery of legal doctrines and its research questions take the form of asking “what is the law?” in particular contexts. At an ontological level this differs from the questions asked by empirical investigations in both the natural and social sciences.

This is perhaps most obvious in a comparison with research in the natural sciences which typically seeks to explain natural phenomena through studying the causal relationships between variables. This is clearly very different from the interpretive qualitative analysis required by doctrinal research which bears a superficial resemblance to the *verstehen* tradition of the social sciences [5].

However, this resemblance with the social sciences is misleading. Scientific research in both the natural and social sciences relies on the collection of empirical data, either as a basis for its theories, or as a means of testing them. In either case therefore, the validity of the research findings is determined by a process of empirical investigation. In contrast, the validity of doctrinal research findings is unaffected by the empirical world. Legal rules are normative in character in that they dictate how individuals ought to behave. They therefore make no attempt either to explain, predict, or even to understand human behaviour. Their sole function is to prescribe it. In short, doctrinal research is not therefore research about law at all. In asking "what is the law?" it takes an internal, participant-orientated epistemological approach to its object of study [6] and, for this reason, is sometimes described as research in law [3].

The actual process of analysis by which doctrines are formulated owes more to the subjective, argument-based methodologies of the humanities than to the more detached data-based analysis of the natural and social sciences. The normative character of the law means that the validity of doctrinal research must inevitably rest upon a consensus theory of truth, rather than on an appeal to an external reality. The underlying moral or theoretical basis for the consensus is a matter of considerable philosophical debate and must remain beyond the scope of this paper. Nevertheless, for present purposes, this could probably best be summarised in terms of a search for internal coherence within the existing body of legal rules.

3.4 Socio-legal Research

In practice, even doctrinal legal analysis usually makes at least some reference to other matters as well as seeking answers that are consistent with the existing body of rules. For example, an uncertain or ambiguous legal ruling can often be more easily interpreted when viewed in its proper historical or social context, or when the interpreter has an adequate understanding of the industry or technology to which it relates. As the researcher begins to take these extraneous matters into account the enquiry begins to move leftwards along the horizontal axis in Figure 2, in the direction of socio-legal research.

There comes a point, towards the left hand side of the matrix, when the ontological nature of the research changes from that of internal enquiry into the meaning of the law, to that of external enquiry into the law as a social entity. This might involve, for example, an evaluation of the effectiveness of a particular piece of legislation in achieving particular social goals, or an examination of the extent to which it is being complied with. In taking an external view of the law each of these examples could be described as research about law rather than research in law. As one continues to move leftwards along the axis one encounters a greater willingness to embrace the epistemologies and methodologies of the social sciences and there comes a point where the terms socio-legal research and empirical legal research are used interchangeably.

3.5 Pure and Applied Legal Research

Finally, let us return to the distinction between pure and applied legal research represented by the vertical axis in Figure 2. Within the context of socio-legal research this distinction simply represents that between pure academic knowledge about the operation of the law and knowledge of the same kind which has been produced with a particular purpose in mind. That purpose will generally be to facilitate a future change, either in the law itself, or in the manner of its administration. Arthurs [3] therefore describes the latter category of research as law reform research and distinguishes this from the production of pure knowledge which he refers to as fundamental research.

The applied form of doctrinal research is concerned with the systematic presentation and explanation of particular legal doctrines and is therefore referred to as the expository tradition in legal research. This form of scholarship has always been the dominant form of academic legal research [4] and, has an important role to play in the development of legal doctrines.

When doctrinal research is undertaken in its pure form it is variously described as legal theory, jurisprudence, or legal philosophy. Although aspects of the present paper draw on conceptual research within this tradition the other three categories of legal research will undoubtedly be of greater practical relevance to the field of construction management.

4. The Role of Law in Applied Construction Management Research

4.1 A Theoretical Underpinning for Practice

The predominantly applied nature of the construction management field has already been noted and this defines the nature of the research undertaken within it. One aspect of construction management research is therefore concerned with developing the necessary theoretical underpinning for the practice of construction management.

Research of this kind, when carried out within the law sub-discipline, may be undertaken on either a doctrinal or socio-legal basis. Unfortunately there is a dearth of both types of research. There is undoubtedly a small amount of high quality socio-legal research undertaken within construction management. Work by Stipanowich [7] on dispute resolution and that by Kennedy, et al [8] on set off clauses in sub contracts may be cited as particularly good examples of this. However, these are the exception and much empirical work within the field, for example on contracts, claims and disputes, lacks the necessary legal content to provide a real basis for law reform by policy makers.

The situation with doctrinal research is equally unsatisfactory, although for different reasons. The construction management field has certainly produced its fair share of expository legal textbooks and many of these achieve a very high standard. The work of Card, Murdoch & Murdoch [9] and that by Murdoch & Hughes [10] certainly fall into this latter category. However, construction management researchers have generally failed to explore difficult areas of law to the level of detail appropriate for journal publication, and this leaves important gaps in the professional knowledge base. By way of example, some of the complex legal issues concerning causation, concurrent delay and global claims might be capable of resolution if subjected to doctrinal study from the unique interdisciplinary construction management research perspective.

4.2 Critical Research

It is submitted that a further aspect of construction management research, within all its sub-disciplines, should be to constantly challenge aspects of practice which are at variance with theory. For present purposes this will be described as a critical research function although this should not be confused with the various ideologically driven forms of research which are often collectively referred to as critical theory research. Critical research is simply that function of scholastic activity which is concerned with challenging assumptions, and with opening up the possibility of debate.

This function has a particular role in the context of academic fields like our own which underpin professional work. By challenging existing practices it can help to ensure that custom and practice reflect the latest standards of professional knowledge, rather than being led either by habit or by uninformed pragmatism. This currently has a special prominence within the UK public services professions due to government support for the concept of evidence based practice [11].

However, with or without government support, a critical approach to all areas of construction management research can play a part in safeguarding and enhancing the standards of custom and practice within the industry. Academic legal research (both doctrinal and socio-legal) can play a part in this process by challenging those areas of practice which have drifted away from their formal legal requirements. This can perform an important role in avoiding civil or criminal liability for those involved. As will be demonstrated towards the end of this paper, it also has the potential to eradicate restrictive professional practices which undermine the productivity, and public credibility, of the industry.

4.3 The Importance of Interdisciplinary Legal Research

Some might argue that the types of research outlined above should be left to those within the mainstream academic legal community. It is suggested that this approach would not be in the best interests of the construction industry, and that in any event it is not a practical proposition. This is for a number of reasons.

Firstly, not all areas of law fall within the province of mainstream legal scholarship. The academic legal community has been heavily influenced by the needs of the legal profession and some areas of law have traditionally been dominated by other professions, including chartered surveying. These areas, including construction law, commercial arbitration and aspects of the law of easements, have therefore received relatively little sustained scholarly attention [12]. In consequence, legal doctrines in these areas remain undeveloped, and the legal requirements for practitioners lack clarity. As the academic legal community has no intention of addressing these areas it is suggested that they must form a legitimate subject for research by scholars within construction management.

Secondly, as already noted, legal rules do not exist in isolation but are only given meaning by being applied to factual situations. In situations involving specialised or complex facts a professional understanding of the factual context is often as important as a mastery of the relevant legal rules. Therefore, even if mainstream legal scholars had the desire to undertake research in the construction management field, they are likely to be less well qualified to do so than those operating in an interdisciplinary construction management context.

Finally, as illustrated by the earlier discussion of legal doctrines, the law is far more than a collection of fixed rules. It is actually a fluid entity which is constantly evolving. This evolution takes place through the ongoing development of doctrines, and through the process of legislative reform. Academic legal research contributes to both of these processes and therefore provides an important opportunity to shape the future direction of the law. It seems right that the construction management academic community should contribute to this process on behalf of the industry that it serves.

5. Two Examples

5.1 Party Wall Practice

The paper concludes by outlining two examples of legal research projects undertaken from within the construction management field. The first project sought to clarify the legal requirements for those acting as appointed surveyors under the Party Wall etc Act 1996. In large part the statute simply extends a piece of legislation which has operated in London since 1855 to the whole of England and Wales. It makes provision for notice to be served on neighbouring owners before construction work is carried out to shared (or “party”) structures. Following service it provides for the appointment of surveyors by each of the neighbouring owners. The surveyors then have power to issue “awards” regulating the conduct of the works, and providing for the payment of compensation where damage is caused to a neighbouring owner’s property.

For generations of surveyors the legislation has been notorious for its ambiguities, inconsistencies and its general lack of clarity. However, as an area of practice undertaken by surveyors rather than the legal profession, its provisions received almost no scholarly attention in over a century of use and the field is characterised by an almost total lack of doctrinal analysis. Surveyors were therefore left to make sense of the legislation as best they could, often, according to Leach [13] by simply “not being too analytical or too inquisitive as to the exact scope of their powers thereunder”.

It was not so much that custom and practice drifted away from the legislation’s formal legal requirements. In the absence of any authoritative legal analysis it was more a case of them developing in parallel to it, guided instead by the largely oral tradition of facts, myths and half-truths which circulated within the profession. This situation may have been tenable when confined within an enclosed geographical and professional community but it could not survive the transition to new pastures where practitioners were eager for authoritative guidance regarding the legal requirements.

The current research project was, in large part, a response to this demand for a more authoritative statement of the law in this area. The detailed nature of the research is beyond the scope of this paper but, in seeking to answer the question: "what is the law?" it, of necessity, adopted a doctrinal approach. It involved an examination of the various legal decisions affecting the legislation [14] together with an analysis of the law as it related to areas of practice which were causing particular difficulty. On this basis it was able to identify the judicial approach when interpreting the legislation [15] and from this, to articulate authoritative statements about the various issues. These included the surveyors' jurisdiction, duties and the nature of their power to award compensation. Through the researcher's involvement in the publication of relevant professional guidance it has also been possible to incorporate the research findings into standard professional practice in the field [16].

5.2 Rights to Light Practice

The second project is currently addressing expert witness work in actions for loss of light. Where a building owner has a legal entitlement to daylight English law establishes that he is entitled to a quantity of light that is sufficient for the normal use of his building, according to "the ordinary notions of mankind". A developer who obstructs the light to his neighbour's building and leaves it with less than this quantity will therefore be liable in nuisance.

Where actions are brought against developers in these circumstances the courts will rely heavily on expert witnesses when judging the sufficiency of the remaining light as well as the valuation of any damages which they decide to award. Experts invariably use a standard approach when deciding these matters. This has been agreed between the small number of practitioners in the field, and is based loosely on the ideas proposed by Waldram in the 1920s [17]. However, a lack of published information makes it extremely difficult for outsiders to gain the necessary expertise for practice in this area and the suspicion is that the existing experts are operating a restrictive practice.

The current project involves testing the validity of the experts' approach from a variety of perspectives and therefore takes a socio-legal stance. It includes an element of doctrinal analysis in questioning whether any aspect of the approach can properly be described as a rule of law. The remaining aspects of the research will use a variety of methodologies to test whether there is any other basis for using this approach, apart from a legal one. This will involve elements of historical archival research as well as experimental and survey research in order to test the validity of its measurement and valuation techniques. Preliminary findings suggest that there is little basis for the current approach, either of a legal or other nature.

6. Conclusions

The paper has explored the interdisciplinary nature of construction management research and has proposed that it should have the capability to provide industry-relevant solutions across the whole range of its sub-disciplines. It has also noted the importance of understanding the different epistemologies and methodologies which are appropriate for the different styles of investigation within the various sub-disciplines.

Within the context of the law sub-discipline it has introduced the concept of legal doctrines. It has examined the central role of doctrinal research within the law subject area and contrasted this with socio-legal research, and with other forms of empirical enquiry. It has suggested that research which asks: “what is the law?” is ontologically different from empirical studies and that, in taking an internal approach to the law, it also differs epistemologically. It has also shown how these differences enable this form of research to address certain types of problems which are not suitable for resolution through empirical enquiry.

The dearth of academic legal research within the construction management field has been noted and it has been suggested that this is ultimately to the detriment of the industry. The benefits of this form of research have been illustrated by reference to two projects which have challenged industry practice in areas which are insufficiently supported by mainstream legal scholarship. It has been proposed that similar investigations could deliver benefits to the industry in other areas of law, particularly those which also fall outside the influence of the legal profession, and which therefore lack an established doctrinal tradition.

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A Comparison of Two UK and US Construction Management Journals

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Abstract

This paper presents additional results of an on-going research aimed at mapping the structure and the evolution of the construction engineering and management (CE&M) discipline and its diffusion around the world. The contents of the papers, published by two leading international academic publications, the *Journal of Construction Engineering and Management* (JCEM) and *Construction Management and Economics* (CME), are assessed over a 12-year period, from 1989 to 2000. The study considers approximately 1,200 papers analyzed according to two main dimensions: 12 types of subject and 5 types of research contribution (insight, theory building/modifying, analytical/systemic constructs, and problem solving) to the field of CE&M. In a broader perspective, the analysis shows the evolution of the construction engineering and management discipline, as represented in the journals. The analyzed data show that the contents of the journals differ in terms of type of research contribution. CME's papers focus more on broader issues, the theoretical aspects of CE&M, and interpretation of construction phenomena, whereas the contributions in JCEM tend to present narrower and pragmatic contents with an emphasis on problem solving, as applied to the "hard" and "soft" aspects of the construction process.

Keywords: Data analysis, construction engineering and management, classification criteria, research contributions.

1. Introduction

Construction engineering and management (CE&M) is a relatively new discipline in the international construction realm. In U.S. practice, CE&M emerged as a result of delivering construction projects with the so-called "Professional Construction Management" approach some forty years ago. The driver of this phenomenon was essentially the result of economic pressures felt by two main groups: 1) private clients who wanted to achieve a better value for their investments and 2) contractors wishing to expand their line of business, away from the cutthroat practice of competitive bidding [1]. Recognizing the increasing technological and organizational complexity of construction projects, some US civil engineering departments concurrently started developing construction management related programs in the late Sixties. Currently these programs are offered all over the world. In the USA these programs tend to be concentrated in civil engineering departments, while in the rest of the Anglo-Saxon world they are also offered by construction, surveying and architecture schools. In recent years CE&M has established itself as an academic and research area that builds upon a long series of publications of scholarly work and debate. Academic journals within any specific discipline play a vital role because they are the primary means for communicating and exchanging research experience, shaping educational programs, and assessing academic careers. Equally important, however, is the historical analysis of the contents – as well as the evolution - of academic journals through bibliometric analysis. In addition bibliometric studies show patterns of evolution within a discipline, particularly as young as CE&M, and play a crucial role in revealing an academic field's structure and the changes in its contents over the years. This type of analysis is also useful in assessing the impact of academic contributions on construction practice. The examination of contributions to the CE&M discipline is not novel. In the past, the content of journals concerned construction-related research issues were investigated to provide a partial map of the discipline of construction management and project management [2], [3]. More recently, the perspectives on construction research were addressed in terms of challenges of US academic communities [4]. This paper contains additional results of an on-going investigation aimed at assessing the past and possible future developments within the CE&M discipline [5], [6]. The study considers the papers published by the *Journal of Construction Engineering and Management* (JCEM) and *Construction Management and Economics* (CME) during a 12-year period, from 1989 to 2000. Approximately 1,200 papers were analyzed according to two main dimensions: the type of subject (based on a 12-item list) and the type of research contribution (insight, theory building/modifying, analytical/systemic constructs, and problem solving) to the field of CE&M.

The paper initially presents some essential information about the two academic journals, including a brief historic introduction, their objectives, and key statistical data. Successively the methodology for data gathering and the classification criteria, according to which the journals' content was analyzed, are addressed. The last part of the paper outlines the breakdown of papers' focus in terms of CE&M subjects and type of research contribution.

2. History, Objectives and Statistical Data of the Journals

JCEM, first published in 1983, is part of a series of periodicals that are promoted and published by the American Society of Civil Engineering (ASCE). Prior to 1983, the topics of that journal had been covered with the title "Journal of Construction Division," which began publication in 1957. The original aim of JCEM was "to advance the science of construction engineering, to harmonize construction practices with design theories, and to advance education and research in construction engineering and management." In practice, the journal's content had a focus on the technical aspects of the CE&M discipline, particularly as applied to the management of civil engineering projects.

CME was founded in 1983 by the publishers E&FN Spon, in conjunction with the founder editor John Bennett at The University of Reading. Originally, one of the principal objectives of the journal was to foster links between industry and academia. In the UK, recently launched CE&M programs were not supported by established theories or research methodologies and, at the same time, practitioners saw the journal as a forum for accelerating positive changes in the industry [1]. Under Bennett's editorship the journal doubled in size, from three yearly issues in 1983 to six issues in 1991. Ranko Bon and Will Hughes took over the editorship of the journal in 1992, and Will Hughes became sole editor in 2003. CME focuses on the management and economics of building and civil engineering as well as the management of built facilities. For the purposes of this study and to facilitate the analysis of historical trends, the statistical data are organized into four 3-year periods of observation that span 12 years, from 1989 to 2000. In the observed period, a combined 1,209 papers appeared in the journals, with 2,486 authorships, as shown in Table 1.

The number of papers published in JCEM increased 29 % in the observed period, from 138 in 1989 to 178 in 2000. In the case of CME in the same period, the number of papers increased at a much higher rate: 146%, from 91 in 1989 to 224 in 2000. The statistics for the "number of authors" (note that some authors did publish more than one paper in any given year) are also shown in Table 1. JCEM experienced 50 % overall increase in the number of authorships, from 267 in 1989 to 400 in 2000, while in CME a steeper increase is noted, approximately 200%, from 159 in 1989 to 482 in 2000. There is also an increase in the ratio of "authors per paper" over the observed period. In both JCEM and CME this ratio increases from 1.93 and 1.75 to 2.15 to 1.96 respectively. Both journals show increasing international contributions over the observed period, particularly by authors from Asia and Oceania. The average rate differential (55% in CME and 28% in JCEM) in terms of international authorship can be explained in the size of UK and US academic communities as well as the traditional UK links with the universities and professions of the Commonwealth countries. Nevertheless JCEM data show that the number of papers originating outside the USA has been increasing at the steady rate of 20% per each 3-year period.

Table 1: Size of journals over 1989-2000 period

JCEM	89-91	92-94	95-97	98-00	89-00
Issues	12	12	12	18	54
Number of Papers	138	162	163	178	641
Number of Authors	267	364	344	400	1375
Authors per Paper	1.93	2.25	2.11	2.25	2.15
Percentage of international authors	0.21	0.25	0.30	0.36	0.28
CME	**89-91**	**92-94**	**95-97**	**98-00**	**89-00**
Issues	14	18	18	20	70
Number of Papers	91	117	136	224	568
Number of Authors	159	219	251	482	1111
Authors per Paper	1.75	1.87	1.85	2.15	1.96
Percentage of international authors	0.55	0.52	0.52	0.59	0.55

3. Gathering of Journal Data and Classification Criteria

The content of this paper builds upon two different databases that were developed separately. A Microsoft Access database was created in previous studies [5], [7] for the classification of the JCEM. This database records the title of each paper, abstract, key words, author/s, their affiliation, and country of origin. Data were drawn from the Civil Engineering Database [8] that is available on line. As for the CME database, a Microsoft Excel file was created by manually inputting data directly from the volumes published during the observed period. Fields for this database include titles, authors' names, organizations, and countries. Those time consuming operations entailed the inputting of approximately 18,000 entries. As stated above, one of the goals of the research was to classify and group the content of the papers according to subjects. To this purpose the following and previously developed classification framework [5] was used:

1. Management of the firm

2. Construction planning and control

3. Site and equipment management

4. Time scheduling

5. Cost estimating and control

6. Construction methods and materials

7. Management of human resources

8. Project management

9. Project delivery systems

10. Contractual issues

11. Industry issues

12. Technology development issues

The order of the above-listed subjects reflects three broad “perspectives” according to which the contents of the papers were interpreted: the first seven subjects focus on the general contractor's operations and business, the following three subjects focus on the project planning, organizing and control by a client (or his/her representative), while the last two subjects focus on issues related to the construction industry at large. A third classification criterion pertained to the type of research contribution published in the journals. The CE&M discipline builds upon an array of knowledge domains from social sciences and engineering science, among others. Since its establishment by practitioners, there have been efforts by the academic community to systematize its knowledge, traditionally based on experience. These efforts encompass exploratory studies of construction phenomena, analytical constructs, modification/application of theories from other disciplines and applications of techniques (often drawn from operation research) to solving soft and hard construction process problems. In this regard Table 2 lists five types of research contributions: 1) Insights, 2) Theory building/modifying, 3) Analytical/systemic constructs, and problem solving in the context of construction management (4) and construction engineering (5). The first three types attempts to capture research efforts of theoretical nature, while the last two reflect contributions with pragmatic intents.

Table 2: Classification criteria of research contributions

TYPE	CONTENTS/PURPOSE	EXAMPLES
1. Insights	General Understanding Analysis and Explanation of Phenomena, Processes	Literature Reviews, Discussions, Personal Experiences, Case Studies, Comparative Analysis
2. Theory Building/Modifying	Application/Adaptation of Theories Substantial Justification of a Research Subject Statistical Analysis Cause/Effect Relationships	Analysis of Surveys and Census Data Methodological Notes for Research
3. Analytical/Systemic Constructs	Synthesis and Representation of Phenomena and Processes	Classification Systems Databases Flowcharts
4. Problem Solving in the Construction Management Context	Application of Engineering Science Mathematical Models Algorithms Deterministic and Nondeterministic methods Decision Making Tools Forecasting	Cost Planning and Control Time Planning and Control Control Systems Resources Allocation Selection Criteria of Contractors Project Delivery Systems Constructability Analysis
5. Problem Solving in the Construction Engineering Context	Application of Engineering Design and Analysis Principles	Robotics Applications Construction Techniques Components and Materials Evaluation/Selection of Physical Technologies Equipment Design Site and Work Area Design

4. Evolution of the Journal Contents

As stated earlier, one of the objectives of the study was to assess the contents of the journals and their evolution over the years. Table 3 shows the counts of the papers (in percentage format) according to the 12 identified subjects over the examined period. In JCEM, these subjects tend to be more uniformly distributed than in the case of CME, in which the first four most frequent subjects account for approximately 57% of all published papers (46% in JCEM). As expected, JCEM's contributions tend to focus on the engineering and "quantitative" dimensions of the CE&M discipline, with emphasis on construction technologies and activities.

Table 3: Classification of papers by subject (in percentage)

	JCEM	**89-91**	**92-94**	**95-97**	**98-00**	**89-00**
1	Management of firm	8.7	8.6	8.6	12.9	9.8
2	Const. planning and control	18.1	12.3	13.5	14.0	14.3
3	Site/equipment management	13.0	13.0	9.8	9.6	11.2
4	Time scheduling	5.1	5.6	5.5	6.7	5.8
5	Cost estimating and control	2.9	4.3	1.8	7.3	4.2
6	Const. methods and materials	13.0	12.3	8.0	6.7	9.8
7	Management of human resources	8.0	12.3	10.4	13.4	11.2
8	Project management	6.5	4.9	8.0	7.3	6.7
9	Project delivery systems	2.2	8.0	9.2	6.2	6.6
10	Contractual Issues	8.0	7.4	8.6	5.6	7.3
11	Industry issues	7.2	4.9	11.7	7.3	7.8
12	Tech. development issues	8.0	6.2	4.9	2.8	5.3
	CME	**89-91**	**92-94**	**95-97**	**98-00**	**89-00**
1	Management of firm	11.0	13.7	10.3	11.6	11.6
2	Const. planning and control	8.8	14.5	6.6	5.4	8.1
3	Site/equipment management	4.4	1.7	2.9	4.5	3.5
4	Time scheduling	1.1	3.4	4.4	3.6	3.3
5	Cost estimating and control	11.0	9.4	9.6	8.0	9.2
6	Const. methods and materials	1.1	5.1	3.7	7.1	4.9
7	Management of human resources	11.0	2.6	3.7	8.0	6.3
8	Project management	12.1	8.5	10.3	15.2	12.1
9	Project delivery systems	5.5	3.4	3.7	4.9	4.4
10	Contractual Issues	4.4	4.3	9.6	5.8	6.2
11	Industry issues	23.1	24.8	28.7	22.3	24.5
12	Tech. development issues	6.6	8.5	6.6	3.6	5.8

These subjects are consistent with the mostly civil engineering base of JCEM's contributors and tend to be addressed in a narrow way. Differently, CME's contents address broader and softer issues, such industry operations and markets as well as management topics both at the firm and project level. These different interests are reflected in the "perspective" dimensions as shown in Table 4. In JCEM the large percentage (66% in the observed period) of papers with a perspective for construction firm operations shows stability over time. The papers suggest an image of a construction firm that self-performs a large share of its work and consequently is interested in optimizing the use of in-house resources. In CME client and industry perspectives prevail over time (53% in the observed period). Undoubtedly, these perspectives reflect the need for change in the UK industry, particularly in terms of professional practice and roles as well as modus operandi (e.g., the persistence of inefficient and labor intensive construction activities) of the industry.

Table 4: Classification by perspective of the papers (in percentage)

	JCEM	**89-91**	**92-94**	**95-97**	**98-00**	**89-00**
1	Construction firm	68.8	68.4	57.6	70.6	66.3
2	Client	16.7	20.3	25.8	19.1	20.6
3	Industry	15.2	11.1	16.6	10.1	13.1
	CME	**89-91**	**92-94**	**95-97**	**98-00**	**89-00**
1	Construction firm	48.4	50.4	41.2	48.2	47.0
2	Client	22.0	16.2	23.5	25.9	22.7
3	Industry	29.7	33.3	35.3	25.9	30.3

It should also be mentioned that the US and UK contexts differ in terms of national priorities for research agendas as well as academic disciplines concerning the construction realm. In this regard a sizeable number of CME papers on industry issues pertain to construction economics, a discipline that is not well established in the USA.

The contents of both journals share a common evolution of interests in two main broad issues, information technology and management of firms. These two issues approximately appear in the first (1989-1994) and second (1995-2000) period of observation respectively. The first period was characterized by the growing use of personal computers and software applications in the industry, as they were applied to the various activities of construction management and operations. The second period coincides with the emergence of new broad issues, such as environmental concerns, public infrastructure systems and market competition that affect the management of construction firms and operations. The second period witnessed a large number of papers on topics such as business and competitive strategies, re-engineering of firms, and inter-firm relationships. These changes reflect a parallel evolution of the CE&M discipline ever since its initial establishment in academic programs. The task of managing projects is no longer concerned with planning and controlling construction only, but also with project programming, financing, design, and selection of construction services. Similarly, the focus of construction firms is not only on successful bidding and production costs reduction, but also on strategies for expanding services and increasing competitiveness (basically away from the traditional "competitive bidding" culture).

5. Classification of Research Contributions

In addition to subjects, journal content was analyzed according to five types of research contributions. As stated before, the first three reflect efforts of a theoretical nature, while the last two encompass applications of engineering science and design to the soft and hard challenges of the construction process. As shown in Table 5, these types of contributions appear to be more equally distributed (with the exception of analytical/systemic construct) in JCEM than in CME in which the small percentage (4%) of contributions of a technological nature is to be noticed. In this last journal theoretical contributions have been increasing over the observed period, from approximately 70% in the 1989-91 years to almost 76% in the 1998-2000 years.

Table 5: Classification by type of research contribution

JCEM	89-91	92-94	95-97	98-00	89-00
1. Insights	33.1	20.5	22.1	18.4	23.1
2. Theory Building/Modifying	15.8	18.0	28.8	24.0	22.0
3. Analytical/Systemic Constructs	10.1	16.8	11.7	14.5	13.4
4. Problem Solving in the Construction Management Context	22.3	21.7	17.2	24.6	21.5
5. Problem Solving in the Construction Engineering Context	18.7	23.0	20.2	18.4	20.1
CME	**89-91**	**92-94**	**95-97**	**98-00**	**89-00**
1. Insights	37.4	42.7	33.1	22.3	31.5
2. Theory Building/Modifying	22.0	25.6	27.9	33.9	28.9
3. Analytical/Systemic Constructs	11.0	7.7	11.0	21.0	14.3
4. Problem Solving in the Construction Management Context	24.2	21.4	25.7	17.4	21.3
5. Problem Solving in the Construction Engineering Context	5.5	2.6	2.2	5.4	4.0

The sizeable share of engineering applications in JCEM (almost 42% in the observed period) and the high rate of theoretical contributions in CME raise the issue of the foundations of CE&M and of the provider of this type of services. While a large number of CME's contributors are concerned with the interpretation of existing industrial phenomena and attempt to reinforce and further develop the discipline domain, JCEM contributors appear to be more focused on narrowly presented issues that can be quantified or modeled and are less concerned with framing these issues into a larger and general reference context. Consequently two different interpretations of the provider of CE&M services emerge. CME's contributors, with their emphasis on interpretations and reflections, seem intent on developing an autonomous professional discipline, as distinct from those of the design or construction professions. JCEM's contributors, most affiliated with ASCE, suggest that CE&M is one of the possible services offered by civil engineers working for consulting or construction firms. Over the years CME and JCEM seem to have consolidated their theoretical and quantitative emphasis respectively. There is evidence, in fact, that international authors have been shaping their contribution according to the editorial intents of the two journals.

6. Conclusions

The analysis of the contents of the two journals under consideration shows that the CE&M discipline has been attracting growing international participation over the years. JCEM's papers tend to focus on the engineering and technological dimensions of the discipline. Without doubt these interests result from the civil engineering base of most of its contributors. Management and industry subjects prevail in CME's papers. This thrust is probably driven by the need for change in the industry, as advocated by several government reports. The UK context, in addition, appears to be characterized by the debate about existing professional roles, particularly in regard to the source of construction management services. The academic orientation of both journals is evident and more pronounced in CME than in JCEM. Notwithstanding the very large amount of theoretical oriented contributions, the temporal analysis of both journals shows few efforts to systematize the various dimensions of the CE&M discipline, particularly in terms of integrating its social science and engineering/science dimensions. Since their establishment in 1983, the journals have witnessed decreasing participation by practitioners in editorial boards and contributions; thus, one opportunity for narrowing the gap between theory and practice has been missed.

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Section II

Knowledge Management

All Good Architecture Leaks - Witticism or Word of Wisdom?

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Abstract

The phrase *"all good architecture leaks"* can be traced back to Oslo School of Architecture (AHO) in the 1970s. The history and context of this phrase now form the basis for a doctorate study on design-related construction defects. Supported by social-anthropological thought models, the frames of interpretation for the phrase were examined [1]. As part of this examination, the driving forces of architecture as a subject were studied supported by simple explanatory models [2]. Data were collected through interviews and detailed literature studies, and resulted in deep insight into the problem area. The study revealed the existence of several phrases about the same phenomenon, i.e. architecture with quality deficiencies. One of these phrases came from a foresighted senior researcher at the Norwegian Building Research Institute (NBI) knowing that being creative and original in architecture can be risky: "*All prize-awarded buildings have multiple defects*." Another was coined by the famous American architect Frank Lloyd Wright: "*If the roof doesn't leak, the architect hasn't been creative enough*" [3]. In a simplified manner, these humorous words of wisdom express a well-known and complex yet tabooed phenomenon. Through the study, two cultural representations have emerged – one belonging to the experimental avant-garde architects, and the other rooted in down-to-earth and practical architect engineers. These opposites nurture a tension that influences the phenomenon of construction defects. The revelation of this mechanism is significant in further research on the topic design-related construction defects.

Keywords: Building defects, leakages, good architecture, noted, ignored.

1. Introduction

As an introduction to the topic, follows a short narrative: "I first heard the sentence 'all good architecture leaks' some time in the early 1980s, when I was a young student at the Oslo School of Architecture (AHO). At the time, leaking houses was old news to me. To explain this, I would like to tell a story from where I grew up. In 1968, my parents moved into a new house with a flat roof. From the very first moment and as soon as it started raining into the snow up on the roof, we had to start removing the wet snow from gullies and joints. Inside, we had to place containers on the floor because of the water dripping down in buckets. Our house was located in a suburban residential area in the outskirts of Reykjavik and was designed by an engineer. It was not a great comfort to know that our neighbour's house was subject to the same phenomenon. His house was designed by a well known architect and had been awarded a prize. When I went home on holiday and told my parents that according to my professor at Architect School "all good architecture leaks", they were furious and a very emotional discussion followed. Once the storm was over, they asked a probing question about the education at this architect school, and what they had allowed me to study."

This story touches the most important elements in this case; the fact that human-made buildings carry inherent potential for defects and deficiencies. This often results in leaks, as mentioned above, but it also to people involved in the same project interpreting and referring to the same phenomenon differently. This appears to be related to the interests they represent.

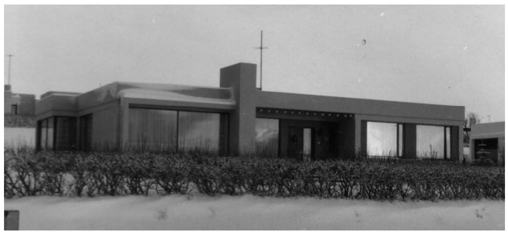

Figure 1 -2: The two buildings in the story, to left Bakkaflöt 1, from 1965, designed by architect Högna Sigurdardotter. To right Bakkaflöt 3 from 1966, design by building engineer Kjartan Sveinsson. (Photo Ævar Hardarson)

The study presented in this article is part of a PhD research project within the priority area Metamorphosis at NTNU in Trondheim. The topic for this PhD project is: Architecture and design-related construction defects. The purpose is to extract new knowledge on how construction defects come into being when new buildings are designed and built. Focus will be on the design process, where a majority of all construction defects originate, but also on the architect's work, as he is an important participant in the discussion on the construction's quality. The main question this research project seeks to answer is: *How and when in the design and production process does the construction defect come into being?* The method developed to research the origin of construction defects is called "The Nebula Metaphor". The basis of this method is that the design process is a highly complex matter which is difficult to describe and predict. It is defined as a co-called "soft or complex system", i.e. a system or process with several elements and numerous interrelations [4]. The name – The Nebula Metaphor – is inspired by a personal and intuitive experience of the design and building process as a cyclic and complex phenomenon. In the imaginations, this process appears as a dynamic shape, a spiral belt of events and relations. The origin of the process, or should we say its genesis, is the formation of pioneer ideas. This phase constitutes the power centre of the process. To discover how and when construction defects come into being, qualitative research methods will be employed. A specific construction project with construction defects is selected. The researcher finds a physical construction defect and tries through examinations, document

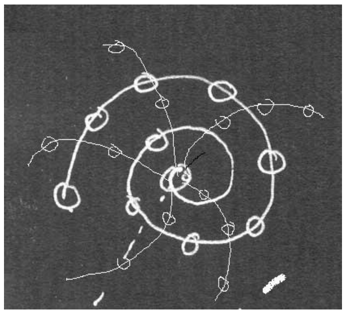

Figure 3: The Nebula Metaphor. The idea abode design and building process as a cyclic and complex phenomenon ore soft system.

analyses, and interviews of the parties involved to shed light on the course of events.

In this article, results from subparts of the research project are presented. The main focus is on examining attitudes and cultural circumstances in the building industry which may influence the construction defect phenomenon. The idea was to explore the phenomenon behind the phrase "*all good architecture leaks*". The question is whether this phrase is a "witticism" or "words of wisdom". Several similar phrases about buildings with quality deficiencies have been revealed. One such phrase is: "*All prize-awarded buildings have multiple defects*" and can be traced back to a research institute. Another is credited to architect Frank Lloyd Wright, who said: "*If the roof doesn't leak, the architect hasn't been creative enough*" [3]. Interviews with relevant participants from this industry have been an important part of this study. The interviewees all had some connection to the topic; they were architects, engineers, researchers and lecturers at Norwegian universities. I also carried out literature studies to find out whether anyone else had studied this topic, and I found that there are very few scientific texts which deal with the topic of design-related construction defects [5].

Assisted by social-anthropological thought models the frames of interpretation for expressions are examined [1]. The driving forces in architecture as a subject are also studied through the reference "*Architects: the Noted and Ignored*" [2]. The study reveals several paradoxes in the way humans think and create buildings. This study has also been used to study how elite persons refer to the phenomenon of construction defects. Cultural representations have emerged from the wings, one belonging to the "architect culture" and the other to the "engineer culture". These two cultures try to entrench themselves in relation to each other and in relation to the discussion on concepts such as architectural quality and quality deficiencies. By use of explanatory models important driving forces were revealed, i.e. the artists on the one side and the practical architect on the other [2]. The revelation of these mechanisms appears to be significant to the interpretation of how design-related construction defects come into being.

2. Theoretic Basis

The study is theoretically anchored in studies within theory of science and social anthropology. These studies can be used to examine the frames of interpretation from which a sentence or a concept originates [1]. The focal issue is how resourceful people, often called ELITE people (i.e. persons who give statements on a subject by virtue of their position and exercise great influence when the content of an opinion is made) speak of a phenomenon. These people may be professors and lecturers at universities, as well as researchers and creative architects. To deepen the study, references explaining the main driving forces in architecture as a subject have been used: "*Architects: the Noted and Ignored*" [2]. According to this reference, Architects can be ordered on a scale from the artistic "avant-garde" to the practical "down-to-earth" architect / engineers A majority of the architects are somewhere in the middle, between the extreme endpoints of the scale. However, in principle is that all want to be artists. This mechanism runs automatically and is supported by the cultural elite. The explanation is that artistic success confers infinitely more status and holds out the lure of immortality, whereas the practical side can only bring in more money

Other concepts of analysis of scientific character are: Knowledge regimes, a concept from Foucault defining the arena from which the object should be discussed and handled. Figured worlds. Figured worlds is another concept, which refers to the implied knowledge that defines normal, rational and possible actions. Both concepts are taken from Gullestad [1].

It became clear that the problem area has been only marginally explored [5]. On this basis, and in accordance with methods developed through the PhD project, I decided to use an explorative approach and qualitative methods. For this reason, interviews have been central when collecting empirical data, where the theoretical anchoring in Kvale [6]. The following guiding questions were formulated: What are the origins of the cited phrases? What are their contexts and impact? What can these phrases tell us about attitudes and the cultural situation in the building industry?

The interviewees were selected qualitatively. The first were picked from the environments to which the phrases had been traced, i.e. AHO and NBI. Other interviewees were picked out based on tip while the interviews were being carried out. Due to my localisation in Trondheim, several interviews were conducted over the phone. Whenever possible, I met the interviewees in person. A majority of the interviews were recorded on tape, always with the interviewee’s consent. Alternatively, notes were taken. Notes and tapes were used as the basis when writing reports for analysis and interpretation. The interviews were conducted between December 2003 and January 2005, a total of 10 interviews. Most of the interviews were conducted in connection with this article, some in connection with the data collection. In the final text, the interviewees are made anonymous by using fictitious names, because the topic is regarded as sensitive and unpleasant to discuss. I find it easier to refer to interview findings this way. Interviewees who are referred to through written sources, on the other hand, are presented with their full names.

In order to ensure a critical focus and as a quality tool for the analysis and the interpretation, certain concepts are employed. These concepts include *critical distance* formulated as “critical preservation of memories and experiences” [1], *critical reflection* on personal prejudices, and strangifying [1]. That involves seeing what is well known from a different or strange perspective. The strangifying can, if successful, puzzle people and trigger reflection. The final paragraph in this article is an attempt of such strangifying.

3. The Findings

This chapter gives an account of findings, both from the literature studies and from the interviews. For a further illustration of the problem, I have also included examples of buildings belonging to the category ‘good architecture with construction defects’.

Defining good architecture or architectural quality seems to be a difficult task (cf. chapter 3.3). The discussion involves time periods, cultures and fashions, at the same times as the general value debate in society is reflected upon. The opinion regarding what constitutes good or poor architecture is partly related to the general spirit of the time, but also to the so-called “good taste”, usually defined by the cultural elite of the subject. However, as time goes by and the buildings reveal their lasting ability and their qualities, some sort of agreement on the characteristics of quality and what may represent our cultural heritage is shaped.

In principle, the words *damage, defect, deficiency, mistake* or *failure* mean the same, i.e. some sort of deviation from a given reference level. However, these words have negative connotations in the ordinary language use. Therefore, in recent terminology the concept *quality deficiency* is used as a collective term. This concept is composed by the Latin *qualitas* (state, nature), which is commonly perceived as a positive term, and *deficiency,* which has negative connotations. The compound *quality deficiency* carries some of the same implications as the phrase "all good architecture leaks", i.e. a battle between the positive and the negative. A subcategory of quality deficiencies includes damage by damp or leaks. Water damage is the largest category – it makes up approximately 2/3 of all construction defects – and the most common cause is water leaks. This damage could be caused by damp being transported to the wrong place, based on given premises, i.e. into the construction or into residential rooms. The causes are many, leaky roofs or walls being the most common. A subcategory of water damage is damp accumulating inside the construction because the hydrogen pressure is too high. In addition comes poor or defective ventilation. This kind of damage has increased in recent years, mostly due to changed living habits, new construction materials and methods. Damp damage is troublesome, as it reduces the technical, aesthetical and functional life of materials and constructions. It also creates biological processes that result in mould and rot, which again cause health problems.

3.1 From Vitruvius to Today’s Architecture

Figure 4 - 6: Leaning Tower of Pisa 1174, (Photo Tore Haugen). Falling water 1935, (Photo Edvard Horton). History Faculty building at Cambridge 1967, *(Photo Dag Nilsen)*

Vitruvius Pollio, Roman architect and engineer, defined architecture using three concepts: "*Utilitas, Venustas, Firmitas*" [7]. In more recent terminology it translates to technique, function and form. This has been the prevailing approach to architecture up until quite recently. With the emergence of functionalism in the 1920s, new strategies and perspectives materialized. One of the characteristics of functionalism was that the ornaments had to go. The clean lines were pursued and the slogan was "the form follows the function". The functionalists also wanted to challenge the natural forces and to use experiments in accordance with the contemporary dominating view of science, positivism. One important characteristics of the functionalist style was the flat roof. One of the great men in modernism, the American architect Frank Lloyd Wright (1867—1959), experimented with form and material like other architects, often producing interesting results. The word is that houses designed by Frank Lloyd Wright always came with a small present – one or more leaks from the roof, naturally causing furious owners. His humorous expression in this connection is quoted in an article on rehabilitation of his famous building Falling water in Mill Run, Pennsylvania: "*If the roof doesn't leak, the architect hasn't been creative enough*," and when the owner of the building continued complaining about the roof leak, Wright said: "*That's how you can tell it's a roof*" [3]. For the design of Falling water, Wright was honoured by the American Institute of Architects with the description "*the best all-time work of American Architecture*" [8]. One of the most famous leakage histories involves Herbert Johnson, owner of Johnson's Wax. At the time when Falling water was designed, Wright designed a domestic house for Johnson in Wisconsin. The story goes that Johnson called Wright during a Thanksgiving dinner to complaint about the leak from a skylight. The water was dripping down on their food. Wright in his chivalry answered "*move the table*" [3].

Another famous avant-garde modernist associated with construction defects is the British architect James Stirling (1926—1992). One of his most famous constructions is the History Faculty building at Cambridge from 1967. Charles Jencks describes the building as one of late modernism's most significant works with new and radical solutions and extensive use of glass [9]. Steward Brand, on the other hand, criticises the modern architecture and comments the issue with the following quote: "*The History Faculty building at Cambridge (1967) leaked torrentially, also dropped its roof tiles dangerously, and faced the wrong way. So the sun cooked its contents – people and books"* [8].

A few more examples are included to further describe the phenomenon of "the good architecture with defect". Many more could have been included, but these are representative and fall under the concept of "the power of example" according to Flyvebjer's definition [10].



Figure 7 - 9: The Nordic house in Reykjavik, the University building in Dragvoll Trondheim, (photo Ævar Hardarson). The Mortensrud church Oslo, (Photo Helge Solberg)

The first example is the Nordic House in Reykjavik from 1968, designed by Alvar Aalto. The building is beautiful and well functioning, boasting many great qualities. It is regarded as an important monument in the architectural history of Iceland. Nevertheless, the owner of the building has been struggling with several roof leaks for over 30 years.

Example number two is the university campus at Dragvoll in Trondheim from 1978, designed by Henning Larsen's architect firm. It is an innovative building with extensive use of glass over an internal communication artery or “street”. Damage by damp has long been a problem in relation to the glass-covered indoor street. *"As colleagues humorously put it – it has to leak to make the architect famous,"* says Per Knutsen, Norwegian architect and project manager for the building project [11]. In an interview, Per Knutsen claims that leaks also occur in ordinary buildings, the ones nobody talks about.

The most recent example in this category is Mortensrud Church in Oslo from 2002, designed by architects Jensen and Skodvin . This building is praised for its high architectural quality and has been awarded several prizes, including three international prizes for outstanding architecture, but it is also associated with leaks. The building project was discussed in an article with the following headline: “*The church that became a constructional hell*” [12].

3.2 The Phrases’ Origin and Context

In this chapter, findings from the interviews are described. The first interviewer is called Thorvald. He was a teacher at AHO in the 1970s and 1980s, and remembers the phrase “all good architecture leaks” very well, but he did not know where it came from. He points to possible connections to visits to England in the 1970s with the students, where constructions by James Sterling were in focus (see previous chapter). The next interviewer is called Johann. He studied architecture at AHO in the late 1970s and early 1980s. Johann associates the phrase quite clearly with Professor Sverre Fehn, since he heard professor Fehn utter this phrase himself. Sverre Fehn (1924) was a professor at AHO from 1971 to 1995. He is one of the most distinguished architects in Norway with a long list of publications. He has also been awarded several national and international prizes. Sverre Fehn is characterised as an avant-garde architect and supporter of the international school, yet still having bonds to the national movement (see report later in this chapter). Several interviewers referred to Sverre Fehn as an inspiring lecturer, with a sense of humour bordering on the absurd. The phrase “*all good architecture leaks*” is given particular meaning coming from Fehn’s own lips, as it is commonly known that some of Fehn’s buildings had construction defects, including leaks. In the interview with Johann, we are told that several phrases concerning the same phenomenon exist. He mentions Mortensrud Church in Oslo, reported to "*leak like a sieve*”. Johann was not familiar with the phrase “*all prize-awarded buildings have multiple defects*”, but in his opinion this phrase could be interpreted in a positive way for the architects, implying that inventive architecture was particularly prone to construction defects because when borders are traversed, room is created for new architecture and eventually new technical solutions. Johann used the expression "*those who venture wins*".

The next interviewer was called Bjørn, a former student at AHO from the 1980s, who clearly recalled the phrase “*all good architecture leaks*”. Bjørn said that when this phrase was uttered, the speaker often added that this did not necessarily mean that houses with leaky roofs were examples of good architecture. He associated the phrase with Knut Støre, lecturer at AHO. Bjørn also refers to Wright's famous utterance "*move the table*", which also was around at the time. Knut Støre lectured at a department called Bygg 1 (Building 1*)*. He is also described as a great humorist. Apparently, Knut Støre proclaimed this phrase both during lectures and when correcting papers, as a sarcastic remark to the international style. To grasp this and the situation at AHO, reference is made to Karl Otto Ellefsen who described the conflict between two groups or schools after the war [13], both represented at AHO. This conflict also existed in architect firms and other schools. The issue was the international style on the one hand and the national style on the other. At AHO, these opposites were represented by the founding fathers Arne Korsmo (the international Korsmo School) and Knut Knutsen (the national Knutsen School). The conflict is described as a kind of internal debate or dualism between leading persons with different architectural views. According to Karl Otto Ellefsen, the Norwegian architects inherited the "artist role" from Korsmo, while the down-to-earth and practical Knutsen School won the battle [13]. Sverre Fehn belonged to the Korsmo School while Knut Støre definitely supported the Knutsen School since Bygg 1 was seen as the Knutsen School's most important bastion. The two lecturers' comments to the phrase "*all good architecture leaks*" should be seen in this connection.

The second phrase, "*all prize-awarded buildings have multiple defects*", was traced back to people working at the Norwegian Building Research Institute (NBI) in Oslo. I first contacted a construction defect senior researcher at the institute, called Ole. He was familiar with the phrase "*all prize-awarded buildings have multiple defects*". He claimed this phrase was a witticism that had emerged in the work place, but was based on the reality that several prize-awarded buildings ended up in NBI's archives of construction defects. He said that the more the architects work on the building to create new solutions, the greater the risk of construction defects. Therefore the logical thing to do would be to follow up with massive technical support, but this did not happen. Ole had heard the phrase "*all good architecture leaks*" and claimed that both phrases described the same phenomenon. According to Ole, it is unlikely that the phrase "*all prize-awarded buildings have multiple defects*" ever will be tested out in a research project, despite this phrase sounding like a research hypothesis. That would have created too strong reactions among "*the breed called architects*", according to Ole, and the Building Research Institute would not profit strategically or financially from such projects.

In order to check the spread of these phrases, more people were interviewed. It has been established that the phrase "*all good architecture leaks*" is unfamiliar to most architects at NTNU. Two lecturers at the Faculty of Architecture who were interviewed had heard the phrase "*all prize-awarded buildings have multiple defects*", uttered by leading persons from the building research environment in Trondheim. One of them thought the phrase was a research hypothesis. Both interviewees expressed the view that the two utterances reflect two groups with opposite interests and could be interpreted as an expression of a certain arrogance and hostile attitude towards each other.

3.3 Architectural Quality

A relevant reference in this debate was the book *Arkitektonisk kvalitet* (Architectural Quality) by Arge and Bleiklie [14]. This book discusses how good architecture or architectural quality comes into being. The main conclusion in this book is that this happens in the interaction between builder and architect. The book's analysis material is built on case studies of four Norwegian, prize-awarded buildings from the 1990s. Both architects and builders were interviewed to find out what characterizes the processes where architectural quality is created. The main criteria for the case selection are that the building project has been awarded a prize, has been published in the architectural press and was designed by renowned architects. I interviewed one of the authors, Kristin Arge. During our conversation, it became clear that construction defects are not discussed as a topic in the book... For this reason, no knowledge was available about the selected and prize-awarded case study objects as to whether or not they have construction defects. According to Arge, this was not a part of their field of interest, but she recalled a remark which touched upon this problem. A project manager, who was interviewed in connection with the study of one of the case objects, mentioned some high-risk technical solutions and concluded: "*we will have to live with that when we are dealing with great architecture.*" During the interview, we discovered that examining prize-awarded buildings with construction defects could be of great professional interest, particularly since this type of research is non-existent. This would involve looking at the evaluations each jury made as regards quality – including quality deficiencies. Arge was familiar with the phrase "*all good architecture leaks*", but had never heard the phrase "*all prize-awarded buildings have multiple defects*", despite having worked at building research in Oslo where the phrase originated. She said these phrases could be interpreted as expressions of a certain level of hostility towards architects. Such attitudes are common among engineers, including those who work with building research, because they feel that architects are not concerned about technical solutions, all they care about is aesthetics, according to Arge. She claimed that architects and engineers have a love and hate relationship.

3.4 From Witticism to Words of Wisdom

To find out whether the phrases had been discussed in the media we conducted an Internet search. The phrases were not found, but we did find a dissertation from NTNU dealing with construction defects. The dissertation was reported in the Norwegian newspaper *Aftenposten* 31 June 2002, and the magazine *Forbrukerrapporten* (lit. The consumer's report) wrote the following: "*prizes are awarded for good architecture, but unfortunately very few prize-awarded buildings have outstanding technical solutions, Mørk writes in his dissertation*" [15]. To examine the basis for this claim, and because it resembled the content of the phrases discussed in this article, the dissertation was procured. The dissertation was on classification and mapping of construction defects with emphasis on quantitative collection of data. The point of interest was that the quotes in the media were taken from a minor paragraph from a large and extensive dissertation. There were no references pointing towards any research or findings from the literature on construction defects which could have been the basis for these claims. So on what were the claims based? Is it possible that this so-called witticism from the Research Institute "*all prize-awarded buildings have multiple defects*", had escaped the closed laboratories and entered the public sphere? Bruno Latour is often quoted with it is difficult to come from being right to having right [16]. Could Latour's principle, in reverse order, have manifested itself?

3.5 The Two Cultures

Several findings point to a tense relationship between architects and engineers. This is strongly emphasized with the phrase "*all prize-awarded buildings have multiple defects*". Expressions such as "hostile towards architects" and "love and hate relationship" are employed. Both expressions could be interpreted as statements revealing two groups with opposite interests. There seems to be tension across institutions and inherited from one generation to the next. The architect thinks the engineer shows little respect for the noble art of architecture, while the engineer claims the architect does not understand engineering. To some people, the phrase "*all good architecture leaks*" is evidence that architects are not interested in technical quality. Several findings suggest two ways of thinking or two cultures, as P.C. Snow described in his essay "The two cultures", where he elaborates on the gap between Natural Science and the Humanities [17]. Students in Trondheim tell jokes and stories pointing in the same direction. One such story is about the engineering student envying the architect student his free and playful studies and later takes revenge. One expression confirming these different ways of thinking is taken from an interview with Sverre Fehn where he talks about his childhood and why he became an architect: "O*ne of [my parent's] close friends was an engineer and taught at the technical college in Trondheim. My parents were very interested in hearing about the conditions there, about the engineering education and the field of engineering in general, and finally, my father asked: What about the architects at the school? The engineer answered:"Architects, they never study, they just run around with large hats and enjoy themselves." It was then I decided to become an architect"* [18]. Through this discussion it has become evident that there is a cultural gap between architects and engineers. This gap could also be described as an internal tension between the few and famous artists and the numerous practically oriented architect engineers, as described by Prak [2].

4. Conclusion

These phrases are undoubtedly humorous, but they also carry a great deal of wisdom. The humorous and deep element in the phrases are the paradoxes they reveal about human ways, but also the fact that constructions created by man have inherent paradoxes, i.e. they could be simultaneously good and poor. The history of architecture includes several such paradoxes, such as the famous Leaning Tower of Pisa and the Opera House in Sidney, which both are major constructional scandals, yet success stories and landmarks. Less famous buildings in the same category which are mentioned in this article are Falling water, History Faculty at Cambridge, The Nordic House, the University campus at Dragvoll, and Mortensrud Church. However, construction defects, including leaks, also occur in ordinary buildings, as reported in this article. A Norwegian proverb seems to be appropriate here: "When it rains on the vicar, it will drip on the sexton."

Both main phrases have been traced back to institutions producing knowledge, that is, a school of architecture and a research institute. The examination of these phrases has been used to study how elite persons refer to a phenomenon and to each other. A situation has emerged from the wings which according to my references could have several names. Some call it two knowledge regimes, while others call it two Figured worlds [1]. The concepts include cognition models both for concrete situations and abstract ideas, where one belongs to the “architect culture” and the other to the “engineering culture”. These two “cultures” try to position themselves in relation to the other. This emerges quite early from different attitudes to concepts such as architectural quality and quality deficiencies. If employing Niels L. Prak’s explanatory model, important driving forces could be indicated [2]. On the one hand, there are the few “avant-garde” architects who constantly try to create something new, experimental and revolutionary. They have their artistic reputations to protect and seek acknowledgement, as this quote implies: *“it has to leak to make the architect famous.”* On the other hand, there are the many "down-to-earth" and practical architect engineers who occasionally have to give their frivolous, artistic colleagues a flick. It appears, however, that both groups live in a mutually dependent relationship, where one has its living of the other’s occupation. The revelation of these mechanisms are significant to further research into the topic design-related construction defects and an understanding of the PhD project's main question: *How and where in the design and production process does the construction defect come into being?*

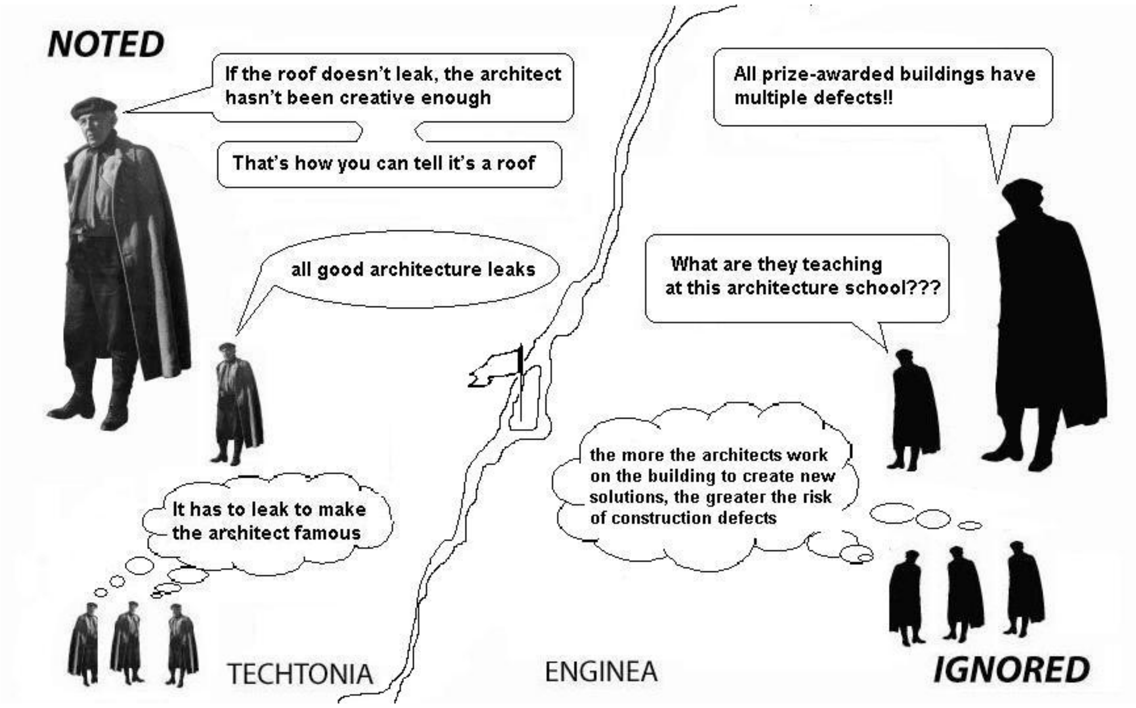

Figure 10. The Theory “Noted and Ignored” related to the sentences analysed in the article

Finally, the principle of “"strangifying” is employed: *Somewhere, in the great universe, there was a planet called Architectura. This was a so-called different planet because it was flat as a pancake and consisted of to areas divided by a rift. These areas were called Techtonia and Enginea. The rift, or split, as some called it, was at times visible, but other times it was beyond any observation. This rift was surrounded by myths regarding its age and origin. Some stories referred to it as a construction defect, while others interpreted this phenomenon as an entrance to the hidden resources of the planet. But the inhabitants of Architectura did not like this rift –*

they dared not cross it and many tales of the situation on the other side were created. They say echtonia was so beautiful, so enchanting, while Enginea was safe and stable.

Acknowledgements

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Managing Project Change in Construction: A Soft Approach

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Abstract

Unplanned changes during the construction phase of projects are inevitable, with potentially adverse implications for project cost, time and quality. Rework that is due to changes can cost between 10-15% of a contract's value. By managing these changes more effectively, these disruptive effects can be minimised or avoided. Therefore, the research study, on which this paper is based on, aimed at developing and testing a toolkit to guide construction practitioners to manage project change in construction. The toolkit is developed based on the findings that are drawn through a comprehensive literature review, followed by case studies. The toolkit captures both soft and hard issues relating to project change and thereby introduces both soft and hard approaches in managing project change. On the hard side, the toolkit first proposes a prediction software tool to 'predict change' and manage it proactively. Second, it proposes a software tool to 'manage the workflow' during change, so that reactive change can be managed efficiently. On the soft side, first the toolkit provides an understanding of dependencies: cause-effect relationships of change, through a detailed framework. This framework (labelled as change dependency framework) assists construction practitioners to understand the complete change management process. Second, an understanding of the significant role of knowledge that the stakeholders bring into the change situation is provided through a set of principles. These principles assist construction practitioners to manage knowledge and teamwork issues during change. While explaining the total contribution of this major research project, the paper will mainly focus on and discuss in detail these soft approaches to change.

Keywords: Project change, change management toolkit, change dependency framework, knowledge management guide

1. Introduction

1.1 Background Research Study

Construction projects often undergo project delays, cost overruns and non-conformance to quality, leading to poor performance and dissatisfied parties (for example see [1] & [2]). An understanding of the driving forces behind such problems is a necessity if the performance of the industry is to be improved. Change can be a major contributor to above raised problems in construction [3] & [4]. The major cost due to change is by the cost of rework and this can amount to 10-15% of contract value [5]. Indirect effects of change are also considerable. Examples of indirect effects are loss of productivity, interruption to workflows and cash flows [6]. These disruptive direct and indirect consequences of project changes demand effective ways of managing them. The appropriate management of change is thus essential to the minimisation of the disruptive effects of change in construction projects.

CIRIA [4] view construction project change as "an alteration or a modification to the pre-existing conditions, assumptions or requirements." These project changes are the additions, deletions or revisions within the scope of a project contract that alter the cost, duration [3] or quality. Effective change management allows change to take place in a controlled way so that viable alternatives are identified, developed and the impact is defined before implementation. Change management in construction is central to the project management process. Previous studies have attempted to approach construction project change management from different perspectives. For example CII [3] and CIRIA [4] take a change management perspective by introducing principles of project change management: anticipate change; recognise change; evaluate change; resolve change; and, learn from change. Love et al [7] take a more technical perspective, by addressing the rework effects of project change. Other studies have approached project change from a process management perspective. Kagioglou et al [8], for example, introduce a separate change management process within the generic design and construction process protocol.

Drawing from these previous approaches to project change management, it is evident that existing solutions only address the problem partially. To reach effective construction project change management, it is important to first gain a complete understanding of the change process throughout a project cycle and second to suggest solutions combining both hard and soft issues of team collaboration and knowledge management. The Managing Change and Dependency in Construction project was initiated to address these issues. The project is funded by the EPSRC and is undertaken collaboratively between The University of Salford, The University of The West of England and Loughborough University. The next section describes the aims and objectives and the methodology of this project.

1.2 Managing Change and Dependency (MCD) Research Project

1.2.1 Aims and Objectives

The aim of this research project is to examine the way in which all of the project elements are co-ordinated towards managing change and to propose a more flexible project co-ordination system that supports the total change management process. In the course of achieving this, the project will consider both hard and soft issues covering the change process. To achieve the research aim the project's objectives are to identify the key task dependency variables for the change process; identify strategies adopted in practice; and, propose an integrated project coordination system to deal with changes.

1.2.2 Methodology

The research commenced with a comprehensive literature review of the issues and implications of unplanned change in construction. The team then captured and represented the attributes of the change process in a taxonomy: nature, causes, consequences and tools. The taxonomy was first validated through internal workshops. In order to sort and structure the research material relating to these four elements, it was necessary to develop change dependency framework. This framework provides an effective way of presenting a process view of the four elements of the change process (see section 3 for a detail account of this framework). Subsequently, the research team conducted exploratory interviews and workshops with industry practitioners to develop, refine and test the framework. Following this first stage, to achieve project objectives in-depth case studies of real life change events were performed. Construction projects were identified according to case study criteria that included projects that have escalated in cost, suffered from delays and/or high degrees of rework. The data were collected through interviews with the construction participants of these selected projects and also through document surveys. Based on the findings of these case studies, a comprehensive toolkit was developed that include both hard and soft approaches to managing project change. The next section briefly explains this complete toolkit.

2. The Managing Change Toolkit

The change management toolkit that is developed by the MCD project is illustrated in Figure 1.

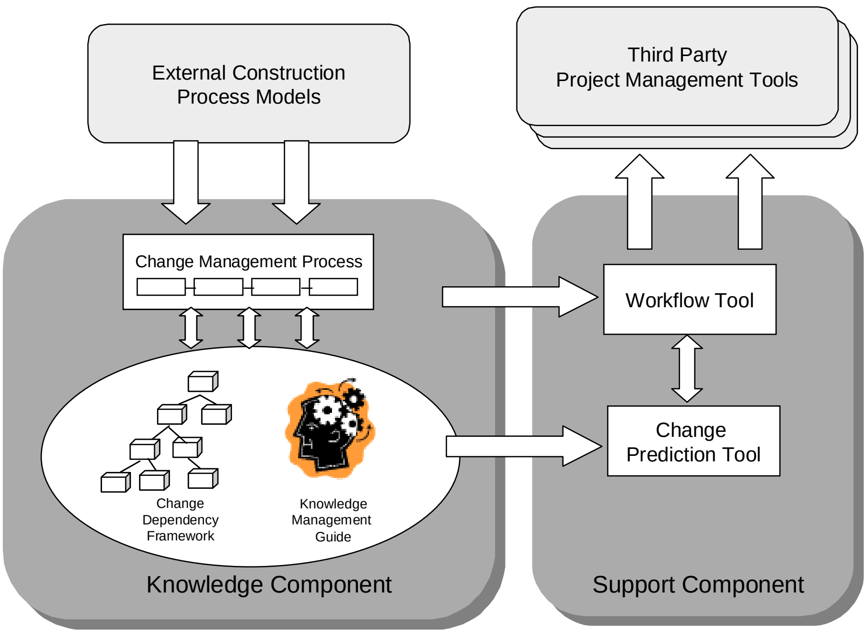

Figure 1: Change Management Toolkit

As Figure 1 depicts the toolkit consists of two main components: a Knowledge Component and a Support Component. The Knowledge Module contains a high-level generic change process that interfaces with a project change dependency framework to identify, evaluate and approve changes. It also contains a Knowledge Management Guide, which can be used either as a standalone guide or to be interrogated and manipulated by the support tools. The Support Tools comprise a change prediction tool that assesses the likelihood of changes occurring and a workflow tool to assess the effect of change on the project programme. The toolkit can be used as a standalone tool during construction projects. It can also be integrated with other project management tools and methodologies, such as external construction process models and third party project management software tools. The toolkit is mainly aimed at organisations involved in the delivery of construction projects. It is designed to prompt thought and discussion of the issues that surround project change. It is envisioned that organisations that use the toolkit will further refine and develop it in accordance with their particular needs. The next section discusses in detail the soft approaches of this toolkit, namely, the development of change dependency framework and the knowledge management guide.

3. Change Dependency Framework

Change dependency framework (subsequently referred to as The Framework) has been developed to consider the cause, consequence and project characteristics in greater detail. The Framework enables users to produce a rich description of the change event. It covers all aspects of project change, including the types of change, causes, effects and the inter-relationship between them. It is, in essence, a taxonomy of construction project change management. The project characteristics considered by The Framework are project scope, team, delivery, execution and control tools. The causes of change are mainly identified from two forces: project level forces and organisational level forces. The Framework identifies direct and indirect consequences. Direct consequences are directly attributable to a change event and will have an identifiable and clearly defined effect on the project, whereas indirect consequences require qualitative measures.

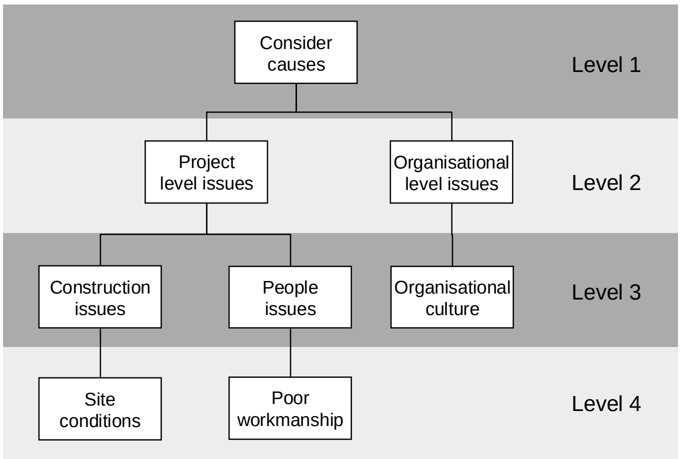

Figure 2: Illustration of Change Dependency Framework Hierarchy

The Framework has a hierarchical structure with four levels (see Figure 2). Level 1 describes the key activities of the generic change management. Levels 2, 3, and 4 are decompositions at increased degree of details. The Figure 2 is an illustration of the Framework, using “Consider causes of change” as an example. The whole Framework is presented as a set of diagrams similar to this illustration. No special or technical skills are required to interpret and use the Framework. Furthermore, the definitions included in this Framework are used directly by the supporting tools of the MCD toolkit. The causes may be examined to help with forecasting and planning activities. The consequences may be examined to help identify changes that have occurred and to aid understanding. The Framework also prompts consideration as to how the project is equipped to manage change. Over the course of several projects a library of change events could be developed that can be integrated with an IT application to compare future scenarios against past cases. The next section explains the knowledge management guide of this toolkit.

4. Knowledge Management Guide

4.1 Importance of Managing Knowledge during Project Change

Managing change in construction projects is a collective problem-solving process. According to previous construction project change literature it is evident that the change problem-solving has been viewed essentially as an information-processing activity [9] & [10] rather than a knowledge intensive activity. Recently, an alternative theory of the firm has been proposed which recognises ‘knowledge as the key asset’ or ‘knowing as a key process’, in delivering organisations’ competitive advantage. This knowledge-based view of the firm [10], [11] & [12], we argue, opens new avenues to approach effective project change management in construction.

Construction literature that address knowledge management, learning and innovation studies, show a trend towards identifying construction problem-solving as a knowledge intensive activity. For example, Winch [14] explains that knowledge and learning are generated in solving problems that involve team discussions and dialogues during the construction process. For such problem-solving to become true innovation the solutions reached for particular problems, should be learned, codified and applied in future projects {15]. Similarly, other learning and innovation literature in construction identifies the importance of integrating project experience to the organisational business processes, to generate learning and innovation (see for example [16] & [17]). However, the extant knowledge-based construction literature is arguably limited in providing an in-depth understanding on the role of knowledge during construction problem-solving and especially during managing change context.

To this end, the general knowledge management literature aids in understanding the fuller role of knowledge during problem situations that is facilitated by team interactions. Accordingly, during shared activities such as problem-solving, individuals bring various forms of knowledge that could be shared and converted into new knowledge [18] & [19]. Most literature identifies two types of knowledge: tacit and explicit. Polanyi [20] explains the tacit knowing by saying that we can know more than we can tell. Tacit knowledge is highly personalised and hard to formalise, making it difficult to share with others. On the other hand, explicit knowledge is codified knowledge, which is transmittable in formal systematic language, often found in rules, policies, procedures, specifications and documents. When considering team knowledge during change events, the theory of knowledge creation [18] shows how a team can advance knowledge and learning through team interactions by different modes: socialisation, externalisation, combination and internalisation. However, as Snowden [21] argues tacit knowledge need not necessarily go through a costly codification process to create new knowledge. This understanding on knowledge conversion offers significant contributions in understanding role of knowledge during shared activities. In order for knowledge, which is generated through change experience to be useful, it needs to pass from project to organisation level and back to subsequent projects. This inter-project learning can emerge when team knowledge is stored and transferred within the organisation for re-use in future projects. Thus, knowledge transfer and learning literature brings useful insights in understanding the inter-project knowledge transfer following project change events. This led to the exploration of the role of knowledge during team interaction as explained in the knowledge management literature.

4.2 Case Study Description

A detailed case study was conducted to address this role of knowledge during project change situations. The case study project comprised a supermarket store extension and refurbishment. The project was procured under Design & Build path. This was one of the series of projects that the client and the project team contracted, on a partnering arrangement. The project duration was 29 weeks and was valued at £ 7.0 million. A major change event was selected and fixed as the unit of analysis for the case study. The change event considered in the selected project was a ‘change in the store flooring design’. The project team members who actively participated in this selected change problem-solving event were interviewed. Accordingly, the interview sample included the D&B Contractor, Architect, Client Agent and the Client. Interviews of 2-hour duration using semi-structured interview guidelines were carried out with each of these team members.

The original floor design of the store required a shut down of the store. However the client realised belatedly that they have not considered the loss of six weeks trading. Therefore the client wanted the D&B contractor to change the original design and consider other floor design options that will minimise the store closure. The floor options evaluation and decision-making went on for about 4 months at the initial stage of the construction works. The change was disruptive and created lot of uncertainty and re-programming. There was a change order system in place to record and communicate change. The project team discussed the change problem mainly at the progress team meetings, which took place fortnightly. In addition, special meetings were held incorporating the specialist knowledge of the flooring sub-contractor. Other modes of communication were e-mails and telephone conversations. The D&B contractor had led this change event involving the client party, architect and the client agents. The team had prior working relationships, being on a partnering arrangement and this had led to good team working. The team was distributed nationally. However the distance barrier had not affected the team collaboration. The team composition was the same throughout the change. Based on the findings, a knowledge management guide was developed, which is explained in detail next.

4.3 Knowledge Management Guidelines

This Guide provides a set of guidelines from knowledge management perspective. The guidelines are explained in this section, which are supported by the case study findings.

- Identify and use team members' expertise in change decision-making.

The extent to which team members hold past knowledge and the extent to which they know one another prior to discussions can affect how they make decisions. Therefore team members need to know who knows what and make effective use of both tacit and explicit knowledge in appropriate balance during the process.

One of the key observations of the empirical study was that team members relied heavily on their previous experience during problem solving. They recalled their past experiences and built upon this knowledge and applied this tacit knowledge to the new situations, rather than referring the codified documents that contained past project lessons in the explicit forms. This was clearly evident in the D&B contractor's statement, "*you always have to relate old knowledge with the new condition, to come with a practical solution. We are dealing with an existing floor. So we did not collect various documents and develop the idea, rather used our experience and the existing knowledge to the practical situation*". This finding is consistent with the construction literature, for example, [22] recognise that construction problem-solving significantly relies on experiential knowledge.

- Consider face-to face settings for change decision-making.

Tacit knowledge that originates at a collective level is the most strategically significant type of knowledge. Therefore it is important to promote team interactions to create this tacit-collective knowledge. Virtual communication techniques are insufficient to this end and face-to-face settings at regular intervals are crucial.

According to case study findings, the decisions related to change problem-solving were mostly considered at team progress meetings, along with e-mail and telephone communication in between these meetings. This finding was confirmed by the Architect's words "*Mostly at meetings issues were discussed in detail*" and the D&B contractor's words "*Decisions were made mainly in the design team meetings where all parties sign up for the final decision*". This reliance on face-to-face settings, despite distance barriers and the availability of virtual collaborative mechanisms, reaffirms that face-to-face settings are the key to team decision-making.

- Create a knowledge-sharing team culture.

It is important to create a team culture that use shared language / narratives and improve personal relationship through trust, care and openness. This can be facilitated by collaborative team approaches such as partnering arrangements, design & build approaches and concurrent engineering.

It was evident from the case study that the collaborative team approaches, in this case the design & build path and especially the partnering arrangement, have created good team working and a long learning curve between the parties. As the D&B contractor stated, "*The long term working arrangements that had been developed over the years had allowed the client projects to operate independently*". However, the D&B contractor further stated "*Due to the long learning curve that the team had developed over the years, it is difficult to bring in new members to the projects and those who worked throughout tend to stay*". Thus, confirms Leonard's [23] views on core capabilities that could lead to core rigidities. Therefore it is important to identify the balance between collaborative arrangements.

- Encourage socialisation activities during managing change.

Tacit knowledge can pass between team members through observation, imitation and practice when they share their knowledge during team discussions. Socialisation activities such as apprenticeships and training; participation in outside activities (such as site visits, fairs and social functions); and informal working arrangements (community of practices and informal networks) can improve members' tacit knowledge base.

It was apparent from the case study that tacit knowledge was created when the team members engaged in shared problem-solving in face-to-face context; that is through socialisation mode. Members tended to learn from each other, thus leading to horizontal learning rather than vertical learning, where juniors learn from seniors. In D&B contractor's words "*Hierarchical learning is limited as there tends to be similar level people involved. But learning across other disciplines is present.*" The client agent too supported this point by stating, "*at project meetings I had opportunity to observe other members and their work.*"

- Encourage members to make their tacit knowledge explicit during team discussions.

Tacit knowledge can be made explicit by effective use of stories, myths, examples, metaphors, analogies and models during team discussions. As well as listening to others' experience and opinions, it is important to encourage each member to express and clarify their thoughts.

The externalisation stage where tacit knowledge is put into explicit knowledge through discussions mainly had taken verbal forms rather than written forms, in the case study project. Even the few written forms that existed were insufficient in detail to be of use in other similar contexts. The D&B contractor emphasised this when he stated, "*Meeting minutes are a way of bringing things that we discussed together. But a drawback is the discussions are not reported in detail at these minutes. We talk for about 40 minutes and include in the minutes what we agreed at last and not the pathway of reaching that decision.*"

- Encourage team members to codify their change experience.

It is important to organise ideas raised in discussions and make conclusions. These need to be codified in documents such as review reports, manuals, databases, publications and/ or computer programmes, in order to disseminate to the wider organisation. Access should be given to all members in the organisation to refer these codified documents.

According to the case study, the existence of combination mode during change events was limited. The codification process after change events was insufficient. D&B contractor stated that "*No special reports were written after the meetings other than these minutes of meetings"* and the architect affirmed "*No formal project review reports were prepared."* However, the views of client were contradictory to the practice as he mentioned, "*We request project review report for large scale projects like this. Otherwise there's no re-collection of what you went through. Because people move on and company changes, without such document we might get to another similar store and find out that we do not have any information on that*."

- Encourage team members to learn after the change experience.

Team members should be provided with time and resources to reflect, learn and experiment from their immediate change experience. Further, team members should be allowed to interact with other members within their individual organisations, so that their experience can be shared through further socialisation.

In terms of internalisation, it was apparent that the team members created new tacit knowledge and generated learning, by going through the change experience. Architect professed, "*In addition to learning how to deal with the new technical issues we have become more flexible and understanding of change.*" D&B contractor stated "*After going through that experience and the problems we encountered, we come to a situation where we can handle that problem a lot quicker and better.*" Even the client admitted that he learnt "*probably to push harder higher up the line and try and get the decisions quicker*" next time.

- Balance personalisation and codification strategies during project change

In summing up, in terms of knowledge conversion and creation, the formation of knowledge conversion cycle, through project changes, was found to be different to that of [18]. The tacit knowledge appears to transfer from socialisation to internalisation while not necessarily passing through the codification stages that involve externalisation and combination modes. Even the limited codification that takes place, such as change record forms and minutes of meetings, lack sufficient detail, to be of use in other similar contexts. Thus, the key conclusion, which can be drawn from the case study investigating the role of knowledge during managing change in construction, is the existence of a process view of knowledge as opposed to an asset view. This process view to knowledge, where knowledge pass from individuals involved through shared activities, limits the transfer and dissemination of knowledge to a wider group. Thus, team members lack the opportunity of learning from others lessons. Therefore, it is very important to create an appropriate balance between asset and process views of knowledge; and decide on the level of codification and dissemination that should be present against the cost of codification and the usability of that knowledge in similar contexts.

5. Conclusions

This report describes a change management toolkit, which aimed at providing support for construction projects. The project Change Dependency Framework ensures that all team members will use standard procedures and terminologies at different phases of a project and for different projects. The Knowledge Management Guide provides advice not only on how to use this system but also on how to better understand project change and change management as well as on how to learn from the process of managing project changes. The system will help a project team to reduce unnecessary changes and to minimise the negative impact of unavoidable changes, thus, help to reduce the project delay and overspending problem of construction projects.

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Are We Catering to the Construction Industry KM Requirements? : A Literature Synthesis

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Abstract

The concept of Knowledge Management is now familiar to the construction industry and various attempts are being made for the effective management of knowledge in the industry. This paper addresses the importance of people factor and tacit knowledge in construction and examines the current focus of knowledge management initiatives to find out the alignment with the industry requirements. Labour and knowledge intensive nature of industry is revealed with challenging aspects of construction performance. Dominant hard model of human resource management is uncovered and finally the mismatch between the current focus and industry KM requirements is unearthed.

Keywords: Tacit knowledge, knowledge worker, knowledge management

1. Introduction

In recent times, the UK construction industry has been forced to critically examine its performance as an industry which lags behind most other industries in terms of technology and productivity [1, 2, 3]. A number of government and academic reports [4, 5, 6] have repeatedly highlighted this issue and the necessity for a fundamental cultural and technical change in the construction industry (CI). It is argued [7, 8] that the publication of Latham's report [4] and the Egan's report [5] as very crucial milestones in the CI addressing issues such as fragmentation, client dissatisfaction, low level of investment in R&D and lack of skills in terms of improving productivity which have adversely affect the performance of the CI. The need for improvements within the industry was so acute with growing pressures exerted by these major reforms.

Within the CI, it is increasingly being acknowledged that Knowledge Management (KM) can bring about the much needed innovation and improved performance the industry requires [9, 10, 11, 12]. This has been further highlighted in a recent survey [7] by Management of Knowledge and Innovation Research Unit of the Open University: the move towards the change initiated by the Latham and the Egan reports as the mostly cited driving force behind the KM in the CI. Yet, the term 'Knowledge Management' is relatively new to construction organisations [11], nevertheless, a growing number of organisations within CI [12] now perceive KM as an integral part of their competitive strategy for providing long term benefits for the organisation. The emphasis on KM reflects the growing realisation that it is a core business concern, particularly in the context of the emerging knowledge economy, where know-how of a company is becoming more important than the traditional sources (capital, land etc) of economic power [13, 14]. There is an emerging importance placed on the people factor in the CI, as one of labour intensive sectors of the economy, which is still considered to be an "under-charted territory" [15] within construction organisations. Yet, this issue has often been ignored or placed with less importance as evident from previous work on KM in CI, which has focused heavily on the delivery of technological solutions [11] probably due to increased concern in Information Technology (IT) in the eighties and early nineties.

The paper aims to highlight the mismatch between KM requirements of CI and its current focus by critically analysing the state of the art KM initiatives and frameworks through a comprehensive literature review and synthesis. Accordingly, paper is organised into three sections: the first section explore the salient features of the CI together with challenging aspects of construction performance and human resource management. The second section examines the apparent limitations and various efforts to improve KM in construction in terms of existing KM initiatives and frameworks, whereas in the final section, the disparity is outlined by considering the industry features, challenges, requirements and KM frameworks in a form of a discussion.

2. Construction – an Overview of Nature, Performance and People Management

Construction is an industry which utilises a variety of separate firms in a temporary multidisciplinary organisation, to produce investment goods like buildings, roads, bridges etc, which are custom built to unique requirements. The industry is generally driven by single and unique projects, each creating and disbanding project teams made up of varying combinations of large and small firms from across the supply chain spectrum. The short-term temporary project based nature is considered as an intrinsic characteristic of construction and industry is considerably more fragmented than many other industries with a much greater concentration of small firms [16]. The scale of small firm activity in the UK CI is considerable, with, in 1999, 99% of UK construction firms having 1-59 staff [17, Table 3.1] and by 2002 delivering some 62% of the industry's workload [18, Table 3.3] and accounting for 122,220 small and medium construction firms in 2003 [16]. Further, the number of professional service firms within CI has risen from 48,202 in 1995 to 52,490 in 1998 [19] and the services offered by these professional service firms are characterised by being highly knowledge intensive in nature [20]. This in a way evident the shift towards the knowledge economy in UK CI and there is significant agreement that the principle means by which this growing body of professional service firms creates value through the successful management of knowledge [21]. The UK Government's Competitiveness White Paper, *Building the Knowledge Driven Economy* [22], refers to more effective use and exploitation of all types of knowledge, particularly in the traditional CI in order to give the UK a competitive edge. In addition, there are a wide range of professionals involved in construction sector, working as an inter-disciplinary team in delivering the construction products. The UK CI employed 19,130 workers per £1 billion output (total of 1,599,000 workers) in 2003 [16], hence considered to be one of the labour intensive sectors of the economy. In this context, CI is perceived as one of the labour and knowledge intensive value creating sectors of the economy.

The value-creating performance of the CI for its clients, however, has often been questioned. Firms in the CI are frequently being blamed for inefficiency of its operations and industry has been accused of being, at its worst, wasteful, inefficient and ineffective [23]. Construction also perceived as an industry which delivers products and services which are often of inappropriate quality and which fails to meet client's demands for price certainty and guaranteed delivery. The industry has long been recognised as having problems in its structure, particularly with fragmentation that has inhibited its performance [4, 5]. Latham's report, *Constructing the team*, was very much concerned with improving the performance of the CI by reducing conflict and construction cost; whilst Rethinking Construction [5] lamented that 'too many of the industry's clients are dissatisfied with its overall performance' (para. 3). This was further extended in Fairclough's report [6] with its reference to the "old fashion" nature of the industry. As a consequence, Fairclough report has identified the need for significant performance improvement as an urgent issue while stating that "the emphasis should be on key competitiveness & productivity" [6]. Thus, the next section discusses the challenges and problems faced by the CI in terms of their performance, which has gained much concerned in recent time due to aforementioned reforms.

2.1 Challenging Aspects of Construction Performance

Despite the importance of business performance measurement in construction, it has received "scant attention" [24] within mainstream construction management literature, particularly concerning its role in "offering real-aid" [24] to improved construction performance. This little attention has resulted construction business performance measurement to rely on "traditional" performance measures, which is considered to be predominantly project specific and profit orientated with hard factors; failing to take account of broader intangible or softer issues. Business performance measurement in construction tends to rely on performance measures, such as efficiency, return on capital employed and profitability. At the construction project level, traditional success criteria centre on the achievement of cost, time and quality targets, failing to take a wider picture into account. These measures have been criticised by a number of authors, mainly because they:

- Over-rely on financial aspects;
- Encourage short-termism;
- Are retrospective (and hence always to some extent out-of-date); and
- Do not accurately reflect the interests of stakeholders.

Thereby, a broader knowledge on organisational technical, structural, contextual and more importantly human factors are essential to better understand why some organisations are more successful than others. Moreover, as Gann [25] criticised, the prevalence of short-term views within the CI has promoted the usage of strategies that yield superior quarterly or annual results even though they may cause long-run ruin for the whole organisation. Also it has been argued [26] that the short term perspective of construction promotes sub-optimisation and hampers innovation and technical development which adversely effect to the organisational performance. In addition, the project based nature of the construction too has fuelled the under performance in the industry to a certain extent. Though the construction team undergoes forming, storming and norming stages of the team development, just when the team has got to its performance level it is disbanded because the project is finished [27]. Hence, this reflects that intrinsic characteristics of the industry too have contributed to hinder its performance in the CI.

However, the ignorance of the people factor within the construction context has contributed to a great extent for the under performance of the industry as lamented by many authors. As contended by Nesan & Holt [28], the issue of the critical role that employees play in fostering an effective construction business (the people factor) has often been overlooked. According to Cooke-Davies [29], “it is people who deliver the projects and not processes and systems”, which gains increased validity in the context of construction, as a labour intensive industry. Hence it is argued [24, 30] that there is a necessity for the CI to define more appropriate performance criteria for both project and organisational level by redefining “traditional” success parameters to consider the knowledge, skills and behaviour inputs which contribute to superior performance. Hence, the following section deals with the human resource aspects of the CI with the view of exploring the current practice within the industry.

2.2 Human Resource Management of the industry

There is established dichotomy in the literature between ‘hard’ and ‘soft’ Human Resource Management (HRM) [16]. The former treats people as a resource to be provided and deploys as necessary to achieve organisational objectives. In contrast, later sees people as valued assets who offer a source of competitive advantage [31]. Construction as an industry which has a reputation for its dominant culture of command and controls consistently emphasises and correlates with the hard model of HRM. Also the culture of subcontracting and self employment marginalises the importance of people management and thereby reflects and reinforces the dominant industry receipt of hard HRM. Even though Dainty et al [30] argued that construction managers have always had significant discretion over problem solving and employment issues, the work employee relations survey [32] which investigated employee participation across twelve sectors revealed that in CI, participation in problem solving groups occurred in only 21% of workplace, which is the second lowest when compared with all other sectors. This dictates that the hard model of HRM dominates not only for the construction labour force, but also for professional and managerial staff.

Soft HRM policies based on empowerment and commitment are much more prevalent within organisations orientated towards creativity [16]. This is true when it comes to the professional service firms within the CI, who compete successfully internationally by investing heavily in knowledge based services. As such it is an urgent matter for the CI to move towards the softer approach based teamwork from hard model of HRM to enhance the collective efforts due to several reasons. Firms within CI frequently claim that ‘people as their greatest asset’ [11] in a situation where literature on HRM repeatedly emphasises the need to treat people as a key resource. This is especially true in relatively low-tech, labour intensive industries such as construction [16]. However, people also represent the most difficult resource for organisations to manage. As highlighted in the intrinsic characteristics of the industry, construction employs extremely diverse range of people from a wide range of occupational cultures and backgrounds, including people in unskilled, craft, managerial and professional positions, challenging to manage people effectively to ensure organisational success. Nevertheless, the importance of the construction worker is highlighted by the fact that industry relies on skill and on the capacity to bring different skills together effectively [33]. Thereby the concept of the knowledge worker has long been important to construction organisations [16] and in recent years, with the growth of the service sector, this emphasis placed on the construction knowledge worker has gradually increased. Having discussed about the significant role of construction worker (people factor) within the industry in terms of intrinsic features, performance and management, the following section examines the current KM initiatives to unearth the importance given to the people factor within such frameworks.

3. Knowledge Management within the Construction Industry

KM is not entirely new to the CI. What is new is the terminology used and the increased awareness that knowledge should be managed in a more structured manner [34]. This has been largely brought about by a number of factors such as the increased global competition, company size, geographical spread and employee turnover [34] and also as a consequence of construction domain becoming highly information intensive [35]. Knowledge is a valuable yet frequently intangible asset. Work by Polanyi [36], Nonaka and Takeuchi [37], divided knowledge into tacit (that which is stored in people’s heads and is acquired through experience) and explicit knowledge (that which could be documented and therefore physically stored). Within construction, the type of knowledge varies enormously, yet gains increase concern on tacit knowledge as a labour intensive industry. Specially, Engineers, Architects and other professionals within CI are not in a position to ‘cut and paste’ best practice [38] from the past due to the unique and the complex nature of the construction projects. They have to draw on the past to find solutions for the future. Tacit knowledge evolves from these shared practices and experience which need to be managed for the project and the organisational success. According to Wetherill et. al [35], knowledge in construction domain can be classified into three categories as illustrated in Table 1.

Table 1: Classification of Knowledge in construction domain

Domain Knowledge	The information available to all companies and is partly stored in electronic data bases
Organisational Knowledge	Company specific and intellectual capital of the firm which also comprises knowledge about the personal skills, project experiences of the employees
Project knowledge	Which includes both project records and the recorded and unrecorded, memory of processes, problems and solutions

By taking a different stance Stahle [39] suggests organisations into three-dimensional system i.e. mechanistic, organic and dynamic nature, depending on the different challenges presented for management of knowledge. Wetherill et. al's classification reflects the organisational hierarchy and when one moves from domain knowledge to project knowledge the concentration on knowledge too moves from explicit to tacit nature, which further highlights the knowledge worker concept in construction. Stahle's suggestion indicates both the management and the production of the knowledge. In a similar sense Moodley et. al [40] contends that the tacit knowledge is developed through the individual or project teams, while the explicit knowledge is created through process, procedures and other routines that can be codified.

Review of current literature reveals numerous definitions and techniques of KM due to wide range of interest, perspectives and issues represented by different authors. These fall mainly into the IT perspective (Explicit knowledge) where authors focus on IT tools to deliver KM solutions [41, 42], the Human Resource (Tacit knowledge) perspective that relies on the people aspect to provide KM solutions [43, 44] and the integrated perspective which acknowledges that both the IT and HR perspectives complement each other [45,46]. Nevertheless, KM is defined as 'process of creating, acquiring, capturing, sharing and using knowledge, wherever it resides, to enhance learning and performance in organisations' [45], which emphasis both aspects. Managing knowledge more effectively offers construction organisations a possible mechanism for improving their performance in times of greater competition [34].

However, despite the interest and the effort put into KM by many leading companies, the discipline is still in its infancy in the CI and is at an embryonic stage in UK construction [21, 34]. As Rezgui [47] cited, there are few key reasons that limit current approaches of KM in CI. Among the key factors for these limitations are;

- Much construction knowledge, by necessity, resides in the minds of the individual working within the domain;
- The intent behind the decisions is often not recorded or documented;
- The individuals who have knowledge about the project are likely to left for another project at the end of the construction stage; hence their input is not captured.

As such all these three limitations indicates the direct correlation with the human factor in the CI and highlights the importance of tacit knowledge and the people-centred approach of the KM to overcome these limitations. This further stresses the importance of the concept of knowledge worker which has long been central to CI performance. Despite difficulties in KM approaches in construction, several KM projects and initiatives have been undertaken, which are outlined in the succeeding section.

3.1 Knowledge Management Frameworks in Construction

CI is evident with paucity of academic research and inadequate empirical studies on KM and even the limited number of studies that have been conducted focused heavily or solely on explicit knowledge [7] and on the role of information technologies [11]. Too often, KM is limited to the appropriation and exploitation of explicit knowledge. Tacit knowledge or people aspect is either ignored or 'converted' to explicit knowledge. In academia, research papers published on KM relevant to construction include: the provision of a KM framework [8]; knowledge transfers between organisations [48]; the role of IT [11]; the impact on construction innovation [10]; the impact on business processes and performance [21]; and case studies within specific construction companies [40]. In addition, following table identifies examples for research projects carried out within construction, in terms of managing knowledge.

Table 2: Research projects in construction to improve KM

CLEVER	Cross-Sectional Learning in the Virtual Enterprise (CLEVER) focused on 3 key aspects of KM- intra-project, inter-project and cross-sectoral- with the view of developing a generic multi-disciplinary framework covering the organisational & cultural implications for knowledge-based businesses.
KnowBiz	Knowledge Management for Improved Business Performance (KnowBiz) concentrated in improving construction organisations business performance through their improved management of the knowledge resources. The development of KM framework and the supporting IT architecture highly emphasised on the use of KM principles to facilitate construction companies in collating and keeping track of the data required for input into key business performance measurement models.
CSanD	Within construction projects, knowledge about sustainability is being developed continuously, but there is little understanding of the best ways to foster the creation of this knowledge, less about how to capture such knowledge and even less about how to ensure that knowledge is available quickly and easily to other individuals and projects. Creating, Sustaining and Disseminating Knowledge for Sustainable construction: tools, methods and architecture (CSanD) aimed at addressing this pertinent problem by developing software tools for capturing and retrieval of relevant knowledge.
E-COGNOS	Methodology, tools and architectures for electronic COnsistent knowledGe maNagement across prOjects and between enterpriSes in the construction domain (E-COGNOS) aimed at specifying and developing an open model-based infrastructure and a set of tools that promote consistent KM within collaborative construction environments with a particular emphasis on a web based infrastructure.
KLICON	Knowledge and Learning In CONstruction (KLICON) focused on the role of IT in capturing and managing knowledge for organisational learning on constructional projects.

As evident, these frameworks have concentrated on different aspects of construction KM other than knowledge workers within the industry, with a very high emphasis on the role of IT. Yet one apparent finding of a research carried out by Management of Knowledge and Innovation Research Unit [7] was that the Information Technology's incapability of transforming tacit knowledge to explicit knowledge and IT as a tool to transform tacit to explicit knowledge was considered as 'a step too far'. Therefore, it was suggested that the extensive use of IT could reduce the chances of face-to-face communication which they considered to have a significant role to play in effective KM. Having examined the state of the art KM initiatives, frameworks and research work in construction; following section outlines and critically discusses the disparity between KM requirements and current focus in CI.

4. Discussion

The labour intensive and knowledge driven nature of the CI together with other intrinsic characters were outlined in the initial section. Further, the importance of recognising the people factor and the necessity of managing construction knowledge worker with softer human resource approach was highlighted in the paper. Yet, as Egan [5] asserted;

"*….much of construction does not yet recognise that its people are its greatest asset and treat them as such. Too much talent is simply wasted, particularly through failure to recognise the significant contribution …… We understand the difficulties posed by the fragmented structure of the industry, but construction cannot afford not to get the best from the people ……*" (para 17; p14).

In this context, Management of Knowledge and Innovation Research Unit [7] has empirically established that problem solving, managing change and innovation as the main triggers of the knowledge production in construction organisations and even out of these three categories, majority of the triggers were associated with problem solving aspects of the professionals. Also in this survey the majority of respondents have noted that they rely on their colleagues as a primary knowledge source and in addition, 'the construction project team' has been cited as the second mostly used knowledge source. Yet another survey [49] of 170 UK construction organisations, indicated that communities of practice as the most widely used technique for KM particularly in large construction organisations. Further, Robinson et al. [21], in a study of the state of KM within the UK construction sector, discovered that over 70% organisations intended to have a KM strategy in place by the end of 2002. The main three reasons for this were:

• The need to encourage continuous improvement (92.5%);

• To share valuable tacit knowledge (88.7%);

• To disseminate best practices (86.8%);

All these empirical studies highlight the importance of the people factor and their tacit knowledge than the explicit knowledge in the construction context. Despite the contextual differences, the tacit knowledge obtained from the colleagues and the project team were considered highly in 'enabling' the respondents to solve the problems they were faced with [7].

As discussed elsewhere, much of the KM frameworks in the CI have orientated towards the management of explicit knowledge via IT tools, in a situation where people-centred tacit approach of KM, as evident from Robinson et al's [21] work, is demanding by the industry. This indicates the mismatch in terms of KM initiatives in the CI. The early focus on KM resulted in technological solutions with a bias towards the use of IT, however, many of these were not successful because they ignored the people required to make them work in construction [34]. More recent work has focused on the importance of HR in KM but these have yet to be developed in terms of concepts and frameworks [50]. It is noted that employee participation in problem solving groups occurs in only 21% of construction workplace when problem solving in the CI is recognised as the major trigger of the knowledge production. Also in a situation where colleagues and project team are considered as the primary knowledge sources and communities of practice as the widely used KM technique, the necessity to shift from hard model of HRM to Soft HRM policies based on empowerment and commitment is much more compelling than ever to foster KM exercises through which CI performance could be enhanced.

5. Conclusion

KM is evolving rapidly but construction organisations are at the emerging level and there is a lot of work to do. The alignment between the KM focus and the KM requirements of the industry is of utmost importance to enhance the performance and to achieve the competitive edge in the CI. This paper has revealed the disparity between the current KM focus and the KM requirements of the construction as a labour intensive and tacit knowledge driven industry. This provides the basis for more empirical research on people centred KM approaches in the CI.

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Managing Knowledge in Construction Disputes

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Abstract

Knowledge has always been recognized as one of the most important assets that one can possess. Various studies have revealed that the management of knowledge is able to increase efficiency as well as enabling professionals in an organization to make more accurate decisions. The construction industry in Hong Kong is highly fragmented, resulting in a considerable number of disputes over contracts and interests, and the resolution of construction disputes by litigation is costly, timely and complicated. This research is conducted to explore views on knowledge management in construction litigation, so as to determine the potential for using knowledge management in construction disputes.

The results of this mixed methodology research show that (1) law firms are more concerned with time efficiency when implementing knowledge management, (2) knowledge management is very helpful in their professional practice, (3) the development of a knowledge management system requires a substantial input of resources, (4) the success of knowledge management is essentially attributable to staff participation and top management support, (5) individual construction companies are not likely to set up a knowledge management system for disputes, and (6) law firms have amalgamated construction disputes in their knowledge management system.

From this study, it seems that there is a need for a knowledge management system for construction disputes. However, further research should be conducted to study the feasibility of setting up an independent and neutral organization to handle sensitive information and tackle the obstacles of mistrust within the industry and the conflict between routine business activities and the extra workload resulting from knowledge management.

Keywords: Construction disputes, knowledge management, litigation

1. Introduction

Disputes are inevitable within the construction industry because of its highly fragmented nature. Although many dispute resolution centers promote alternative dispute resolution (ADR), litigation and arbitration are still common forms of dispute resolution used by construction companies. Court cases can consume millions of dollars and take years to settle, thus how legal professionals advise and assist their clients in resolving such disputes has important implications for the construction industry.

Knowledge management has many advantages in assisting lawyers to effectively deliver appropriate information and advice in a timely manner. An effective knowledge management system can also respond to an emerging trend for major clients to ask for an arrangement whereby they are connected electronically to a law firm's knowledge base.

Law firms represent an industry that seems very well suited to conducting knowledge management investigations. They are knowledge intensive, and the use of advanced technology may well transform these organizations in the future [1]. Therefore knowledge management practice in law firms can be a good reference for the construction industry in implementing knowledge management. The market for construction litigation is huge and there appear to be many advantages and little risk to applying knowledge management in construction disputes. Nevertheless, there has been little research into the application of such specialized systems in Hong Kong. This research aims at exploring this issue.

2. Management of Construction Litigation

The nature of the construction process is that it is a multi-party business that involves an owner, consultants, a general or prime contractor, subcontractors, and other related parties such as insurers, sureties, and lenders, all with different needs. These parties are expected to cooperate and coordinate their efforts. One party's failure to perform is likely to place a burden, financial or otherwise, on one or more of the other parties.

There are various factors that lead to conflicts and disputes in a construction project. They include different interpretation of contract clauses, inadequacy of plans, workmanship, defects, lack of supplies, tort, lack of insurance proof, indemnity, third person liability, safety and non-payment [2]. The most common way to deal with contractual disputes in construction is to file a lawsuit.

Litigation can be expensive and complicated as it involves many court procedures; in addition, it takes a long time to bring a case to a conclusion [3]. In Hong Kong, the waiting time simply for a case to be heard at the High Court exceeded 190 days in 2003 and is expected to be longer in 2004 due to the growing backlog of cases [4], and this does not take into account the preliminary arrangements, discovery of documents, submission of evidence and other complicated procedures in litigation. The quantum of the legal fees for such proceedings will likely exceed the amount of compensation payable, if any. There are also many complications, such as the fact that lawsuits must be brought before expiry of the relevant statutes of limitation, or handling the tedious discovery process [5]. Thus construction litigation places a heavy burden on the disputants if the case cannot be skillfully and efficiently settled; locating lawyers who are familiar with construction disputes for appropriate advice is crucial to clients if they are to minimize costs and delays and ensure that correct decisions are made.

2.1 The Role of the Legal Profession in Construction Litigation

The implications of the involvement of legal counsel in the construction industry is not limited to the representation of clients at trial, but also involves the leverage of expertise and experience to provide commercially focused solutions and to minimize the litigation process, thereby achieving the client's business objectives [6]. Cautious construction companies will, prior to signing any construction contract, retain lawyers who are experienced in construction matters, to review the contract terms and identify future problems, as well as specifying how they will be resolved in the course of the project. This measure will allow them to make early pragmatic determination of the cause of construction disputes and identify the parties responsible for any defective performance, resulting in an efficient resolution and savings in future litigation.

2.2 Knowledge Management for Legal Practices

Compared with other professions acting in an advisory capacity on construction claims, law firms are in the most need of managing knowledge for the purpose of feeding information and giving advice to their clients. In common law jurisdictions, where the Doctrine of Precedent is in practice, court cases are of utmost importance to lawyers for giving legal advice to their clients. If not efficiently managed, the vast amount of cases accumulated from several hundred years ago to the most recent, many other cases that did not go to trial and were settled out of court, and the know-how in settling cases without trial, would be difficult for lawyers to use in the course of performing their duties. In a recent survey of the use of information technology by law firms [7] the top three challenges identified were:

- Improving efficiency
- Winning new clients
- Improving client service

These challenges have led to a growing interest in knowledge management as an alternative means of creating a competitive edge [8] so that law firms can create, share, and use knowledge effectively [9].

The Head of Education and Know-how in a city law firm stated that,

> "firms that do efficiently accumulate their wisdom in an accessible manner are likely to produce immediate advantages for their clients and to compete more successfully" [10]

Knowledge management is a viable means of enabling law firms to identify and capture their 'knowledge assets' and to protect them well, so that legal counsels can fully exploit them as a source of competitive advantage [11]. This knowledge-based view of a law firm suggests that knowledge assets may produce long-term sustainable competitive advantage for the firm because knowledge-based resources are socially complex to understand and difficult for other firms to imitate [12].

The significance of knowledge management was further confirmed by the research findings of the 2001/2 Global Law Firm Knowledge Management Survey [13], in which leading law firms in the US, the UK and Australia recognized that knowledge management is a key business driver.

According to Rusanow [14], law firms typically place heavy emphasis on core explicit legal knowledge, as shown in Table 1:

Table 1: Knowledge types in legal firms

Knowledge Types	**1.1.1 Categories**
Externally created knowledge	Case law, commentary and interpretation
	Legislation and commentary
Internally created knowledge	Best practice (or model) documents
	Precedent (or form) documents

Externally created knowledge is supplied to the firm by external providers such as commercial publishers or the government: typically made available in the library either electronically or in hard copy, such files can be easily accessed by lawyers. According to research by Taylor [15], the external sources of legal information and knowledge most frequently used by legal professionals in the UK are journals (100%), followed by official publications (84%), textbooks (76%) and law reports (69%).

Internally created knowledge can be found in (1) specific documents that a firm has identified as high quality and a good example of its work product, and that could be re-used in a similar factual situation, and (2) precedent documents, which are generic documents in whose development the firm invests for use in many matters, and which will be collected and reused to ensure the baseline quality of work done, as well as to maintain consistency and save time.

Other than traditional legal knowledge, there are many categories of non-legal knowledge that are critical to a lawyer in giving sound advice tailored to the unique needs of clients [14]. For example, in construction litigation, lawyers must recognize the construction industry’s operation and job specification. Therefore, knowledge from expert or external consultant forms an essential part of the knowledge of a construction litigation lawyer.

3. Research Methodology

In Hong Kong, the practice of knowledge management in legal practices is a relatively new concept. The government has positioned Hong Kong as a legal service center in the region, and Hong Kong is also renowned for its international construction standards. However, escalating litigation costs place a burden on construction litigants. This study aims to explore the prospect of nurturing knowledge management for construction litigation in Hong Kong by studying the adoption of knowledge management in law firms.

The exploratory study was mainly conducted through a structured questionnaire. The aim of using a questionnaire was to collect objective data about knowledge management practices from legal service providers. Questionnaires were sent via mail to 170 law firms with construction litigation practices in Hong Kong, which were selected from the law firm directory of The Law Society of Hong Kong. The total number of questionnaires received was 35, yielding a response rate was 20.59%.

4. Data Analysis

About 70% of the respondents had been working in the firm for more than 6 years, and all were experienced lawyers (Table 2). Also, about half of the respondents were partners in their firms, therefore they had a thorough understanding of their firms' management polices and knowledge management practices (Table 3).

Table 2: Respondents' work experience

Work Experience in the Firm	Frequency	Percentage
< 3 years	5	14.29
3-5 years	5	14.29
6-10 years	11	31.43
>10years	14	40.00
Total	35	100

Table 3: Respondents' positions within their firms

Position in the Firm	Frequency	Percentage
Solicitor/ Lawyer	13	37.14
Senior Solicitor	6	17.14
Partner	16	45.71
Total	35	100

4.1 Knowledge Management Practice in Law Firms

Regarding the respondents' knowledge and preferences with regard to knowledge management, 42.86% of the respondents' firms had adopted knowledge management, 22.86% preferred not to adopt knowledge management and 34.29% had never heard of knowledge management. In other words, 57.15% of law firms did not know about or choose to use knowledge management.

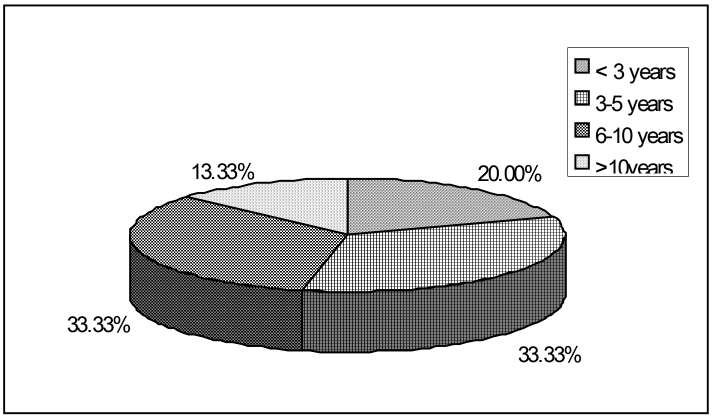

Figure 1: Years of implementing knowledge management system

Of the 15 respondents whose firms had adopted knowledge management, a high percentage said their firms had been using knowledge management for three to ten years, thus it seems that there is mature knowledge management development in law firms, even up to 15 years. This indicates that most of the respondents whose firms had developed a knowledge management system were working for large corporations with long histories.

4.2 Knowledge Management Practice Analysis

Among the 15 respondents whose firms had adopted knowledge management, 14 were in firms that had a company library and 13 in firms that used presentations/seminars for knowledge management practice. These popular methods were followed by discussion (11) and internet-based information sharing systems (10) (Table 4).

Fewer than 30% of law firms applied project briefings or special interest group meetings as their knowledge management practice, and only one respondent's firm used newsgroups.

When respondents were asked about which knowledge management practice is helpful in the process of resolving construction dispute, the result was quite similar to the frequency rank, with the same number thinking that the company library and discussion are helpful. Also, only 20% of respondents thought project briefings, special interest group meetings and news cutting services were helpful, and no respondent thought newsgroups to be helpful.

About 86.67% of the responses indicated that practice group meetings are helpful. It was found that many law firms did not have practice group meetings, but that most thought them helpful. Table 4 shows the frequency and effectiveness ranks of various knowledge management practices.

Another significant difference was in the adoption of presentations/seminars: only 33.33% of lawyers considered them useful; however most of the law firms (86.67%) had adopted them as a knowledge management practice.

Table 4: Adoption frequency and effectiveness of various knowledge management practices

Knowledge Management Practices	**Frequency Rank**	**Effectiveness Rank**
Company library	1	1
Presentations /seminars	2	8
Discussion	3	3
Internet-based information sharing system	4	5
Workshop	5	5
Practical checklists and guidance notes	6	4
Record keeping	7	7
Practice group meeting	8	2
Reviewing sessions	9	8
News cutting service	9	10
Project briefing	11	10
Special interest group meeting	12	10
Newsgroup	13	13

4.3 Analysis of Reasons for Adopting Knowledge Management

The results indicate that respondents were mostly concerned with working efficiency: time saving and improved operational efficiency, with 100% answering agree and strongly agree (Table 5). Other reasons, such as improving documentary administration, enhancing effectiveness in problem solving and enhancing knowledge transfer, were also the expected outcome of adopting knowledge management.

However, some respondents might have been confused on the issue of protection of intellectual capital, resulting in the lowest mean score of 4.13. Protecting intellectual capital was not regarded as a reason for adopting knowledge management.

Table 5: Reasons supporting the adoption of knowledge management practices

Reasons Supporting the Adoption of Knowledge Management Practices	Mean
Saving time	5.53
Improving operational efficiency	5.53
Improving quality of work	5.47
Saving resources	5.40
Improving documentary administration	5.33
Enhancing effectiveness in problem solving	5.27
Enhancing knowledge transfer	5.27
Encouraging knowledge sharing	5.20
Risk management	5.00
Improving communication	4.93
Enhancing improvement incentive	4.80
Protection of intellectual capital	4.13

4.4 Analysis of Factors Leading to Effective Knowledge Management

There are mainly four types of factors that lead to effective knowledge management: human, organizational, technical and financial. Colleagues' attitudes, with the highest mean of 5.8, colleagues' experience and trust between colleagues, with means of 5.27 and 5.07 respectively, were the major human factors leading to successful knowledge management application. Technical support was the second highest mean, 5.67, and is considered essential for the development of knowledge management systems, such as databases and internet-based knowledge sharing systems. In addition, resources/funding (5.47) were the third most important factor for setting up a knowledge management system. It is interesting to note that confidentiality was ranked as the lowest of all the factors, which indicated that it is not a significant reason for not implementing knowledge management (Table 6).

Table 6: Factors leading to effective knowledge management

Factors Leading to Effective Knowledge Management	**Mean**
Colleagues' attitudes	5.80
Technical support	5.67
Resources / funding	5.47
Company culture	5.33
Incentives	5.27
Colleagues' experience	5.27
Top management's commitment	5.20
Trust between colleagues	5.07
Learning atmosphere	5.00
Knowledge management policy	4.93
Recognition of belonging	4.73
Complication of the litigation	4.73
Clarity of information	4.27
Confidentiality of the litigation information	4.00

4.5 Analysis of Difficulties in Adopting Knowledge Management

All respondents agreed that the major difficulties were lack of time and lack of staff incentive, since setting up a knowledge management system and capturing knowledge were time consuming. Resources/funding ranked as the third most difficult aspects in adopting knowledge management, accounting for the mean score of 5.67. It should be noted that poor communication skills and competitive working environment were considered as least problematic (Table 7).

Table 7: Difficulties encountered in adopting knowledge management

Difficulties in Adopting Knowledge Management	Mean
Lack of time	5.87
Lack of staff incentive	5.73
Lack of resources / funding	5.67
No knowledge sharing culture	5.00
Lack of top management support	4.93
Lack of collaboration between staff	4.79
Lack of technical support	4.47
Staff lack of construction knowledge	4.00
Lack of experienced colleagues	3.87
Poor communication skills	3.71
Competitive working environment	3.53

4.6 Analysis of Benefits Generated by Knowledge Management Initiatives

Enhancing worker capability and enriching professional knowledge were the most important benefits generated from knowledge management from the individual point of view; both means were 5.4. From the company's viewpoint, knowledge management can improve quality of work (5.27) and service quality (5.2), which are important for the sustained business of a company. Though increasing company revenue was ranked lowest as a benefit, it is anticipated that profitability can be increased through proper management of a firm's knowledge (Table 8).

Table 8: Benefits generated by knowledge management initiatives

Benefits Generated by Knowledge Management Initiatives	**Mean**
Enhancing employee capability	5.40
Enriching professional knowledge	5.40
Improving quality of work	5.27
Improving service quality	5.20
Increasing working morale	5.13
Enhancing dispute resolution progress	5.07
Improving problem solving efficiency	5.06
Increasing client satisfaction	4.93
Enhancing organizational competitiveness	4.87
Raising company professional image	4.80
Improving communication	4.67
Enhancing innovation	4.53
Increasing company revenue	4.47

4.7 Analysis of Reasons for Not Adopting Knowledge Management

The main reason for not adopting knowledge management was immature development of knowledge management systems, scoring the highest mean of 4.63. Lack of incentive and high cost were the second most frequently-cited reasons for not applying knowledge management, both with a mean score of 4.5. Other reasons include lack of time and lack of top management support (Table 9).

Table 9: Reasons for not applying knowledge management

Reasons for NOT Applying Knowledge Management	Mean
Immature development of knowledge management systems	4.63
Lack of incentive	4.50
High cost of establishing knowledge management system	4.50
Lack of time	4.38
Lack of top management support	4.13
Company culture	4.13
Lack of technical support	4.13
Security	3.88
Lack of construction knowledge	3.88
Knowledge management is not practical	3.75
Insufficient understanding about knowledge management	3.75
Lack of resources / funding	3.50

5. Conclusions

This research explores the implementation of knowledge management practices in legal firms which specialize in construction disputes. It reveals that less than half of the respondents' firms had knowledge management systems in place. For those who did implement knowledge management, some had just started up the system and others had already had one in place for 15 years. It can be concluded that knowledge management practices vary from firm to firm and are most often adopted in large organizations.

Law firms rely heavily on their company library for knowledge and find it effective. Respondents found practice group meetings effective but did not use them frequently in their offices. When asked about reasons for adopting knowledge management, the top three selected are time saving, improving operational efficiency and quality of work, which are understandably important issues in today's competitive fee environment.

The three main factors leading to effective knowledge management included colleagues' attitudes, technical support, and resources/funding. Confidentiality was not deemed to be an important issue in this respect. Respondents found that lack of time, staff incentives and resources/funding were the major difficulties in affecting the implementation of knowledge management. Firms which implemented knowledge management found that enhancing employees' capability and their professional knowledge were key benefits generated from their knowledge management initiatives. This basically gives employees the right knowledge to deal with the right tasks.

When firms were asked about the reasons for not adopting knowledge management, they cited the immature development of knowledge management systems, lack of incentive and high cost. Though it is far from common for law firms in Hong Kong to adopt knowledge management practices, it is anticipated that with the advance in technological solutions, immense competition pressures both locally and internationally and increasing client demands, knowledge management will soon be a fad in the legal industry as the "proof of the pudding is in the eating".

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Challenges of Knowledge Management in Public Construction Projects

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Abstract

This paper focuses on the basics of knowledge management by exploring offered, needed and wanted knowledge. We aim at exploring what kind of issues are critical for succeeding in projects. The research is qualitative aiming at exploring the challenges of knowledge management in construction projects. The paper is based on four case studies in public construction projects in Finland.

We study how difficult it is to know what kind of knowledge you need in a project and how people filter the information they don't want to learn. This filtering may also include issues that they should learn. People do not utilize all the available knowledge recourses. These resources might be people or tools that give new knowledge e.g. on the state of the building they are renovating. The offered knowledge may not be trustable, or you don't need the knowledge at a moment.

Keywords: Knowledge management, project, construction, learning

1. Introduction

The article is based on the findings of the PROLAB-project. The project seeks to find solutions for how the information can effectively be used in project management, specially in construction projects, what kind of procedures help the management of the knowledge and how the obstacles for efficient ways of administrating the information can be removed. These obstacles can be either related to use of new technology or to organization culture.

This paper focuses on the basics of knowledge management by exploring offered, needed and wanted knowledge in construction projects. We aim at exploring what kind of issues are critical for succeeding. However, we don't discuss on success criteria rather we try to find out how knowledge resources are critical and why they are accessed or even more why they might not be accessed. We also discuss how the managers are able to know what offered knowledge they should take seriously in the project environment?

2. Method

The research is qualitative aiming at illustrating the challenges of knowledge management in construction projects. The paper is based on literature review and four case studies in public construction projects in Finland, in three towns. The amount of inhabitants in these towns vary between 23 000 to 185 000. The four construction projects we have been studying were:

- Renovation of a school that had mould problems, total area 7000 m^2 and budget 4 000 000 euros. Project started 1997 and ended 2002.

- Renovation and partly new construction of a school that had mould problems, total area 3000 m^2 and budget 2 7 000 000 euros. Project started 1998 and ended 2005.

- Hospital for senior sitizens, the renovation of the nursing home, total area 7 000 m^2 and budget 5 700 000 euros. Project started 1996 and is still going on.

- University project, 24 000 m^2. Alteration of an old factory into a university and partly new construction. The project started 1997 and was finished at 2004.

We used theme interviews as a means to collect information but we have also collected artefacts of the projects like drawings, memos, and observed the meetings in two projects also we have action research going on in two towns – there we discuss new ways of organizing the knowledge management in the construction projects.

3. Information, Knowledge and Knowledge Management

Knowledge is often defined to be meaningful information. Knowledge is derived from information. What makes difference between data and information is their *organisation* and what makes difference between information and knowledge is their *interpretation* [1]. Knowledge is understanding one gains through experience, reasoning, intuition, and learning. We expand our knowledge when others share their knowledge. New knowledge is born when we combine our knowledge with the knowledge of the others. Wisdom and insight can be included to the definition of knowledge. *Wisdom* is the utilization of accumulated knowledge. [2]

Lillrank [4] defines information in a hierarchic manner. According to him, data are symbolic representations of entities, properties and their states. They have content and form that allow storage, transfer, and retrieval. Data are turned into information by giving them meaning and context. Thus information includes data, meaning, and context. The difference between information and knowledge is in their way to approach the world. Information reveals how the world *is*, knowledge tells how it *works*. Lillrank [4] is interested in information's ability to elicit meaning. Meaning is a function of data and their context. This can be formalized as $M=f(D,C)$ where M is meaning of data, D is data, C is context, and f is the relevant knowledge of how world works in this framework. By means of f an actor can assign meaning to the piece of data and turn it into information. This happens in a communicative act or sensemaking process where the meaning is negotiated with other agents. Negotiation in informal, open system is needed, if data, context, and the knowledge function are fuzzy, otherwise formal, closed systems can do.

Perkins [5] is also more interested in the way information is used or processed than its content. His perspective is called *the access framework.* Access characteristics are divided into four categories. *Knowledge* concerns what kind of knowledge is available: procedural knowledge, facts, strategies, and routines. *Representation* concerns how the knowledge is represented. *Retrieval* concerns how and how effectively knowledge can be found. *Construction* concerns the system's capacity to assemble the new knowledge structures from the pieces of knowledge.

There seem to be no agreement on definitions of "data", "information", "knowledge", or "wisdom". However, there are some aspects all of the authors share. Whether information or knowledge are seen as separate concepts or not, the transformation of data to knowledge or information happens when meaning is given to them. This happens in a shared action, where meaning is negotiated or constructed together with other actors. If we want to improve the processes of project management we should concentrate on the concept of meaning.

According to Bruner [7] our culturally adapted life is based on shared meanings and shared modes for negotiating differences in meaning and interpretations. He describes how this negotiation takes place by means of *narratives*. Narratives are not needed if things proceed in an ordinary fashion. We have theories of mind called "folk psychology" or "common sense": normative descriptions of what makes human beings "tick", what one can expect situations to be like, what our minds and those of others are like, what are possible modes of life and so on. We believe (or "know") that the world is organized in a certain way, that we want certain things, that people hold believes about the past and the future. We believe in coherence of all these believes, that people should not want "irrational" things. We have very strong opinions about how things *should be* and how one *should behave*.

If these rules are broken, narratives are constructed. We need some kind of an explanation of why things are not in the way they should be. Narrative are stories which bring the world together again. They give a reason or meaning to the deviation from canonical cultural patterns. [7, 10] In the world of narratives, no explanation is needed for ordinary or routine, only the non-routine or a deviation needs an explanation or special meaning. The greater the deviation, the more meaning-making is needed.

The problem with the human thinking is, that we are *not* computers or we cannot even be compared to computers. The matter of team work and the shared meaning building has probably more to do with literature and related fields than with IT-studies. If we talk about literature, we talk about qualitative material and qualitative analysis. Bruner seemed to be very strict about this. Studying human thinking as computing is as wise as studying computer programs as literature. They are two different things.

Quinn et al. [8] divided the knowledge of a organisation at four levels: (1) know what: the cognitive knowledge; (2) know how: the ability to translate bookish (know what) knowledge into real world results; (3) know why: the ability to take the know how to unknown interactions; and (4) care why: self motivated creativity, this level of knowledge exists in a organisation's culture.

Knowledge management (KM) is according to Brelade and Harman [3] obtaining and using resources to create an environment in which individuals have an access to information and in which individuals obtain, share and use these information to raise the level of their knowledge. In addition to this individuals are encouraged and enabled to obtain new information for organization.

4. Knowledge Creation and Learning

Knowledge is one of the most important assets in organizations today. The big question is, as Davenport and Prusak [9] state, how organizations manage what they know? Knowledge management should naturally begin with realizing what kind of knowledge is there to be managed. Järvinen [11] has introduced five different types of knowledge:

1. Conseptualized knowledge
2. Operationalized knowledge
3. Cultural knowledge
4. Grounded knowledge
5. Coded knowledge.

Järvinen also defines what kind of forms these different types of knowledge get in organizations (see figure 1).

Types of resourses \ Types of know-ledge	Consept-ualized knowledge	Operatio-nalized knowledge	Cultural knowledge	Grounded Knowledge	Coded knowledge
Long-lasting phycical resources				Products, prototypes, process technology	
Human resources (individual)	fatcs, concepts, principles etc.	know-how, tacit knowledge	Behaviral models, values		
Human resourses (community)	Collective beliefs	cooperation and commu-nication procedures	Values, goals, ideologies etc.	Roles, routines, rituals	
Knowledge and infor. base resourses					Web-pages, databases, manuals etc.

Figure 1. *Types of knowledge and resources [11].*

Next step in knowledge management is to assure that new knowledge, that is needed, is created and also used by right people. Nonaka and Takeuchi [14] have introduced a model of knowledge conversion (see figure 2).

From \ To	Tacit knowledge	Explicit knowledge
Tacit	Socialization	Externalization
Explicit	Internalization	Combination

Figure2. *Four models of knowledge conversion [14].*

Explicit knowledge is something formal and systematic. It can be expressed in words and numbers and it can be easily communicated and shared. Tacit knowledge is subjective and intuitive and thus difficult to process or to be transmitted.[15]

The process of turning either tacit or explicit knowledge into tacit knowledge means learning. A person or a group learns something new so that they internalize the matter. After this learning process it is likely that this person or group is also able to utilize the new knowledge acquired.

The process of externalization means turning tacit knowledge into explicit so that it can be shared. Sometimes this process can be very difficult because people don't necessarily even know what they know. People can learn (internalize) new things and new knowledge in almost every situation and they may begin to use this new knowledge e.g. at their work but how to put it into visible form?

Combining explicit knowledge with another piece of explicit knowledge may create new knowledge under favorable circumstances. And then the circle begins again: learning, sharing, creating new knowledge. And all these processes are needed in every organization.

Miller [13] argues that "there appears to be no one formal or structured process that an organization can adopt to lead it along the pathway to successful workplace learning and to become a learning organization". In practice several different methods are applied from very strict formal ways, like courses, to informal, almost "invisible" ways, like communities of practice (see e.g. [12]; [6]). However, Garvin [22] has provided a three stages that must be gone through if learning is wanted to be useful. The first stage is cognitive, in which new ideas are welcomed as well as new ways of thinking. The second stage is behavioral change that means that the new ideas of the first stage are learnt and used in practice. The third change is the effect of the two earlier into the organization.

5. Available and Used Knowledge Resources

The knowledge resources are studied in the following order (1) long lasting, (2) knowledge and information based resources, (3) individual, and (4) human community resources. The aim is to study the resource types and discuss the availability and level of usage of each resource.

5.1 Long-lasting Physical Resources

The grounded knowledge of the construction projects can be found for example, in the products like windows. The window is not designed from the very beginning they can be picked up from the available lists. The ventilation systems are tailored for the building but after that there is a lot of knowledge grounded in the system. The designers cannot study all the possible technical solutions often they are satisfied in the first solution that fits the purpose.

5.2 Knowledge and Information Based Resources

Knowledge and information based resources are the type of knowledge that is possible to be delivered in written format. It is often called coded knowledge. In practise it may be manuals, drawings, text books, papers, web-pages and other computer systems. Laudon and Laudon [19] classify IS for knowledge management into four main categories (1) those for creating knowledge (knowledge work systems); (2) those for processing knowledge (office automation systems; (3) those for sharing knowledge (group collaboration systems; (4) those for capturing and codifying knowledge (artificial intelligence system). I would say all these systems are knowledge and information based resources.

The designers produce coded knowledge for the construction companies so that they are able to construct the building. The coded knowledge is saved in drawings in 2D or 3D format and specifications or product models. The rules like fire protection or load bearing calculation methods can be partly saved into the computer system and they help the designer to select the right protection style etc.

Also we have systems to give contracting guidelines so that we don't need to invent every time everything from the beginning we have for example, general conditions of contract or task lists of an architect or designer or developer. All this information can be called coded knowledge that can be picked up nowadays from the computer system earlier they were in paper format(in Finlad so called RT cards, in Germany DIN norms) .

We have also found out that if the coded knowledge system is changed the parties have difficulties to take it – like if the project definition plan was made more accurate than normally, people had difficulties to capture the knowledge from them. The project manager even had doubts that they ever read this document. One of the project managers also said he has not time to study all the documents when they bid. The site manger also was sorry to tell that he is not able to study all of them before he starts to work at site.

5.3 Human Resources Individual

The individuals may be inside the project core team or external to that. Each individual plays his/her part in the project based on his knowledge about co-operation and about the construction process. The end users seldom have any previous knowledge on construction project and the need to learn everything but the construction experts often have some experience that is similar to the project at a hand. All of them try to create some kind of mental model what is happening in the project.

A knowledge structure is a mental template that individuals impose on an information environment to give it form and meaning. There are basically two fundamentally different ways of structuring knowledge: theory driven or data driven. Often the professionals in our case projects use the theory driven approach. This way of thinking help individual to understand but they also encourage in stereotypic thinking and; subvert controlled information processing; fill data gaps with typical but perhaps inaccurate information; prompt one to ignore discrepant and possibly important information of the existing knowledge structure; and inhibit creative problem solving [15]. This could be seen in design stage as thinking “this is just a normal school”. That makes it impossible to listen to the real needs of the customer and the normal solutions are seen the only possible solutions.

An individual works often in a routine way and he avoids to evaluate the meaning of every fact. We don’t even use our existing knowledge in an optimal way. I know it is wise to write down in the diary all the meetings but I fail sometimes to write some meetings there or I can fail reading the diary in the morning and miss the very important meeting. I should have known better to write it down, to read it and prepare for the meeting but for some reason I did not do that. The failures are very human. The invaluable issues get less attention like the site manager might find it difficult “writing the official minutes of the meeting”. An other example of this type of happening: the site manager has the information of the building, he has planned the timetable and he is able to understand that the purchasing process should start e.g. two months before the windows are installed but he fails to read the documents and he has to improvise and make the man to do something else before the installation of the windows.

Sometimes the project manager has questioned the need to change the design during the renovation when new things appear and the internal expert claims that the predesigned solution is no longer valid. What the internal expert has to do: he/she has to find external experts that support his/her opinions. In a hasty situation this might not happen and the internal expert might either change the design solution without negotiating or just leave it as it is knowing that the solution will not last – perhaps he she writes about it in the logbook of the site.

5.4 Human Resources Community

The collective beliefs rule our behaviour. One example of such behaviour is the belief that the architect is not able to think economically. As a matter of fact, we assume to know the values, goals and ideologies of our partners though every party is individual. However, the cultural knowledge is important to be understood. For example, the nurses found first the contractors rough and difficult to cope. The co-operation became more comfortable after the both parties had learned to know each other. At the end nurses got all the needed knowledge in order to be able to run the hospital during the construction period. After learning they could create procedures to deliver the information. The knowledge of the other culture was needed before the co-operation and communication procedures were established.

Organisational knowledge structures rely on consensus and agreement [16, 17, 18]. That can be seen as shared frames of reference, recall past events, the creation of events, the creation of stories and myths, vicarious learning, unlearning and memories [20]. This can be seen in construction project in the stories of heroic site managers or engineers that solve impossible problems. But also in the stories that the computer databank cannot help in management of the project or that the software is not yet mature enough to be used. These stories are sources of knowledge for the practitioners. The key decision makers sense and interpret the changing environmental events, they frame them in problem formulation process as problems, opportunities, or crisis [20]. Socio-political themes, such as credibility and power, influence the acceptance of the view [21]. It is so understandable that an old expert can select rather freely his perception to the usage of new knowledge like computer systems. People let them to select their opinions freely younger ones have to show first how much they understand before they are heard. This kind of thinking - who knows what - is accepted and the people who have either formal or informal power can easily reject new ways of working or new knowledge – if they tell that this is not trustable the rest of the construction team believes and everybody shall continue their normal life.

In the beginning of the design process the people that shall utilize the building communicate their knowledge to the professionals – how much we as professionals are able to learn and understand is questionable. Often it might also happen that the power filter effects on who is asked. The managers of the office or kitchen or what ever function are asked what kind of spaces should be designed. The majority of the users have very little possibilities to tell what kind of spaces might make their work more effective. It is most demanding to study all the ideas coming from the workplace – how many should be asked and how to organise this process. Currently it is believed that the managers organise the opinions of their subordinates. This process is seldom supported by the construction project. Following four examples of the knowledge management processes give ideas what kind of possibilities there are available:

- mock up room: different groups of the end users are able to study the mock up room and test how it functions. The comments can be either gathered on the table or the whole group can join in the test use of the space. This kind of rooms were found most helpful

- activity cards help the users to describe what kind of qualities of the space are most important to them. The architect could then read the cards and discuss with the user groups later

- excursions with the professionals. The comments of the users help the designers to understand the special needs of that building. However, the users the designers most often make the excursions separately.

- ICT tools like virtual models of the building make the design solutions visible.

When the designers study the building with the users there should also be the cost expert involved. Since often new ideas appear that often raise the costs and before further developing the ideas there should be some kind of critical checkpoint with the whole project group. However often the users get the impression that when asked what they want they are not heard when the critical checking and finding out how the expenses can be lowered is done without them and the end result is introduced to them afterwards – then they claim that the most important things might be eliminated while the more expensive nice but not that important things were left.

6. Conclusions

The study revealed the many folded resources of knowledge and that it is impossible to utilize all the available resources. The study also showed that the knowledge resources are difficult to be utilised since we as human beings are not able to change our perceptions easily but also that the human communities might prevent the fast changes.

Construction project concern many people and at best the co-operation inspires to better solutions but at worst we hurt the feelings of other person and that might affect their motivation. The individuals can learn to think in two ways data driven and theory driven. Data driven approach helps us to see things in new ways and listen to other parties. Theory driven approach understands the phenomenon via theories and makes it possible to understand without all the facts but misunderstanding is also possible.

There are not available any formal process that ensure the needed utilisation of the knowledge resources. We can, however, claim that by sharing the knowledge with the project parties they are able to improve the knowledge management and gain new innovative solutions to the old problems and that the mental models can be broken in the teams. If you work alone your mental models are not tested as often.

In the introduction we promised to discuss how the managers are able to know what offered knowledge they should take seriously in the project environment. More relevant question is how the manager enables the learning in the team and makes people to learn form each other. The project manager is not able to select what knowledge is reliable but he should be able to know how the project is organised and who knows what and so who is able to select what offered knowledge should be taken seriously.

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Effectiveness of National Institutions in Stimulating Construction Innovation in Singapore

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Abstract

In this paper, based on qualitative system dynamics, a model of the National System of Innovation (NSI) is structured with five main NSI actors: National Institutions; Contactors; Clients; Related and Supporting Firms; and Government. This model, based on the assumption that the key motivation for innovation by national institutions is based on maximising social benefits, highlights the social pressure for higher productivity and quality as the main driving force of construction innovation by national institutions within the NSI. The research findings indicate that technological advance from national institutions that cultivates a competitive environment is able to first, stimulate a direct increase in construction innovation, and second, develop industry clusters that increase contractors' research capabilities. This will encourage contractors to adopt innovation as a long-term strategy towards sustainable competitiveness. Hence, we concluded that the ease of adoption of technological advancements is paramount towards developing a competitive industry and it should be considered in national institutions' innovation policies.

Keywords: Institutions, innovation, national system of innovation, system dynamics

1. Introduction

1.1 Overview of the Role of National Institutions in Construction

Institutions are understood as norms, habits and rules that are deeply ingrained in society and which have a major role in determining how people relate to each other and how they learn and use their knowledge. National institutions involve exploring the national mechanisms, such as governments, higher educational systems and national research institutes, by which new technologies are developed and transferred. Various authors [1,2,3] have recently brought the concept of national institutions as a linkage between the common infrastructures of the national economy and that of the cluster network of inter-relating firms in the theories of National System of Innovation (NSI). It encompasses the "transfer factors" that strongly influence the effectiveness of linkages, the flows of information and skills, and the absorptions of learning that are essential to the firm's innovative capabilities.

In construction today, the dynamic environments that challenge firms in their management of technological innovations and uncertainties across organizational boundaries reveal the significance of the role of national institutions in the industry. Technical know-how is required first, for construction firms to stay viable in the market, and second, as a key tool for competition through innovation. Hence, many researchers [4,5] have identified institutionalised R&D as a possible major source of technological innovation in construction and have asserted the urgency of an increased level of investment in construction R&D. In this paper, using System Dynamics, a model of the NSI is developed to illustrate the role of national institutions in stimulating higher levels of construction innovation within the NSI. From this, it is intended to investigate: (1) the role and effectiveness of national institutions within a nation in stimulating construction innovation; and (2) the possibilities of reformulating national institutional policies to attain higher levels of innovation in Singapore's construction industry.

The time is right for an analysis of the role of national institutions in facilitating higher levels of construction innovation at the national level to be undertaken as it is believed that the innovation capabilities of firms are key sources of competitive prowess and that such capabilities can be built by national action [6]. Moreover, lessons from developed nations such as the US, UK and Japan illustrate the need to provide a rationale for further investments in national institutions as they are progressively facing the economic challenge of decreasing return in research investments [7]. On the other hand, there is a growth in private associations that are modernizing management and improving technical capabilities without the aid of governments [8]. Examples include Japan Association of Representative General Contractors, the Electric Power Research Institute (EPRI) in the US and a consortium of major private building owners in Canada. These associations have sponsored major studies to develop new technologies for application in their industries [9]. Hence, there is a need for a realignment of investments in national institutions and the reconfiguration of policies to achieve greater efficiency and effectiveness from strategies within the dynamic environment of the NSI.

1.2 Methodology

In this research study, secondary statistical data for Singapore were collected from various publications such as the *Yearbook of Statistics* and the *Economic Survey Series*. By applying non-linear regression to the data for the period 1981-2002, a logical deduction of the significance of each NSI determinant to construction innovation is obtained. This aided the formulation of the NSI model. The Statistical Package for the Social Sciences (SPSS) was used for the non-linear regression, while Vensim was used for the development of the NSI system model.

2. The National System of Innovation

2.1 Logics of the National System of Innovation towards Construction Innovation

Freeman defines the NSI as the network of actors in the public and private sectors whose activities and interactions initiate, modify, and diffuse innovations and implement them in new products, production processes, and organizational forms [1]. However, there is no agreement on the key structural elements of an NSI, and how these elements interact to determine the overall pace and performance of innovative activities in a country, as there is no one best way to describe the elements in an NSI when countries are of diverse sizes, stages of economic development, and history [2]. However, from the various models of the NSI [3,10,11], four similar and critical variables can be highlighted:

1. Firms and their dynamic factors that shape innovation in firms such as networks of collaboration with firms' related and supporting industries, rivalry and firms' structure;

2. Transfer Factors – issues of effectiveness of linkages for the transfer and absorption of technology, knowledge and skills between firms and the common innovation infrastructure;

3. Common innovation infrastructure – basic national infrastructures that sets the range of opportunities for innovation such as human capital and financial resources available for R&D activity, policy choices and other national resource commitments; and

4. Chance – a set of factors that exist regardless of any consideration of innovation.

Hence, the main actors of the NSI in the context of the construction industry are:

1. Firms and their dynamic factors that shape innovations in firms - *Construction Clients, Contractors, Suppliers* and other *Related and Supporting Firms*;

2. Transfer Factors – *National Institutions*; and

3. Common innovation infrastructure- *Government.*

Chance, is not considered here because, as Schumpeter observed, innovation cannot take place if the economy does not develop and is only dragged along by changes in the surrounding world. Thus, the impact of chance on innovation, is secondary, and depends on the internal efforts of the economy rather than on chance [12].

In the NSI model presented in this paper, the NSI actors are within the national system of interconnecting relationships, which are further linked by NSI variables. Together, under influence of the key driver for construction innovation through the national institutions, they structure the level of construction innovation undertaken by contractors. The relationships between the NSI variables and the level of construction innovation are defined by the results of the non-linear regression analysis in Table 1. Table 2 shows the measurement frameworks of these variables. The findings from the regression analysis demonstrate that all proposed NSI variables are significant except for Construction Demand. This may be due to quality aspects that are imperfectly reflected in the national income accounts indicator. Nonetheless, abiding by the regression results, construction demand is not included in the model.

Table 1: Non-Linear Regression Analysis Results

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	42.300	41.631		1.016	.326
CLP	-1.168	.652	-.137	-1.793	.093
GDP	-16.720	7.199	-.731	-2.323	.035
INI	.372	.123	.422	2.020	.009
RDC	4.111	1.568	.671	1.622	.019
COM	5.578	2.956	.200	1.887	.079
CBL	4.846	5.304	.272	.914	.375

Dependent Variable: LCI

R^2 value = 0.933

Table 2: Variables Measurement Framework

Connotation	Variables / factors	Measurement framework
LCI	Local Contractor's Level of Investment in Innovation	Annual R&D Expenditure of Local Contractors
CLP	Construction Labour Productivity	Annual Percentage Change in Labour Productivity
GDP	Construction Demand	Construction's Industry's Contribution to Gross Domestic Product
INI	National Investments in National Institutions	Annual R&D conducted by Government and National Institutions
RDC	R&D Capability of Local Contractors	FTE[#] value of R&D Personnel in Construction
COM	Level of Competitiveness in the Construction Industry	Annual Number of New Construction Companies
CBL	Available funds for private investments in construction innovation	Bank Loans and Advances to Local Contractors

[#] FTE: Full Time Equivalent – Methodology based on Frascati Manual (OECD, 2002)

2.2 Driver of Construction Innovation in the National System of Innovation through National Institutions

Markets do not necessarily lead to the optimal production and distribution of knowledge because there are gaps between the social and private returns from investment in knowledge-enhancing activities. While private returns refer to the gains realized by the firm undertaking the R&D, social returns are based on total benefits, including those flowing to consumers and other producers [13]. Seaden notes that the social rate of return from construction R&D may be several times larger than the private rate of return [9]. A survey by Griliches indicated that between one-third and two-thirds of the economic benefits of R&D are not captured by the organization that performs it [14]. Mansfield observes that innovation in construction materials presents one of the greatest divides, with social returns of 96 percent and only 9 percent of private returns [15]. This may be because construction is a fragmented and highly competitive industry; firms are less able to translate their innovations into higher profits due to their low shares of the market [9]. Hence, there is a call for the government to be involved in controlling these positive externalities, and national institutions offer a possible avenue to do so. Since innovation is largely a public good with social desirability often exceeding those of the market, this desirability is revealed through the social desire for higher construction productivity and quality. Thus, the difference between the desired construction productivity and quality and the actual level provided by the contractors present the pressure on the national institutions to reduce the 'spillover effects' of knowledge benefits. Hence in this paper, the social pressure for innovation is recognised as the key driver of innovation by national institutions in the NSI.

3. Dynamism of National Institutions in the Construction Industry

3.1 The System Dynamics Approach

A qualitative systems model was applied that utilises causal loop diagrams to structure a modeller's understanding of the system and to show the dynamics of the variables. Table 3 presents the typical denotations used in causal loop diagramming. At the foundation of the systems approach are positive feedbacks, represented by a reinforcing loop that is structured by none or an even number of negative links, and negative feedbacks, represented by a balancing loop that is structured by an odd number of negative links. Positive feedback creates reinforcing behaviour and negative feedback moderates a system towards an equilibrium position. The identification of positive and negative feedback structures in economic and management systems is key to modelling and gaining insight into the development of innovation [16].

Table 3: Denotations for Causal Loop Diagramming (Sterman 2000)

Types of causal links	Denotations
	All else remaining equal, an increase (decrease) in the variable 'A' increases (decreases) the variable 'B' above (below) what it would otherwise have been.
	All else remaining equal, an increase (decrease) in the variable 'A' decreases (increases) the variable 'B' below (above) what it would otherwise have been.

3.2 Creation of a Competitive Environment for Stimulation of Construction Innovation

Institutional economists note that the influence of a country's institutions on its ability to master and advance technology is a central way that the institutions affect economic performance [17]. Similarly, Porter observes that national institutions provide the basic factors constraining national or any specific industry's productivity [18]. This relationship is reflected in the NSI model, where construction productivity and quality directly influence the pressure on the national institutions' decisions in deploying resources for technological advancements (Figure 1, B1). Following feedback B1, a higher deployment of resources in national institutions' R&D will lead to technological advances that will once again affect the level of productivity by increasing it at the pace of the adoption of the new knowledge by contractors. However, this flow of activities is structured as a balancing loop that will moderate the level of productivity and quality towards an equilibrium position over time. For example, with a higher level of productivity and quality, there will be lower social pressure on the national institutions to innovate, hence, lowering the pace of technological advancements that will in turn reduce the level of construction productivity.

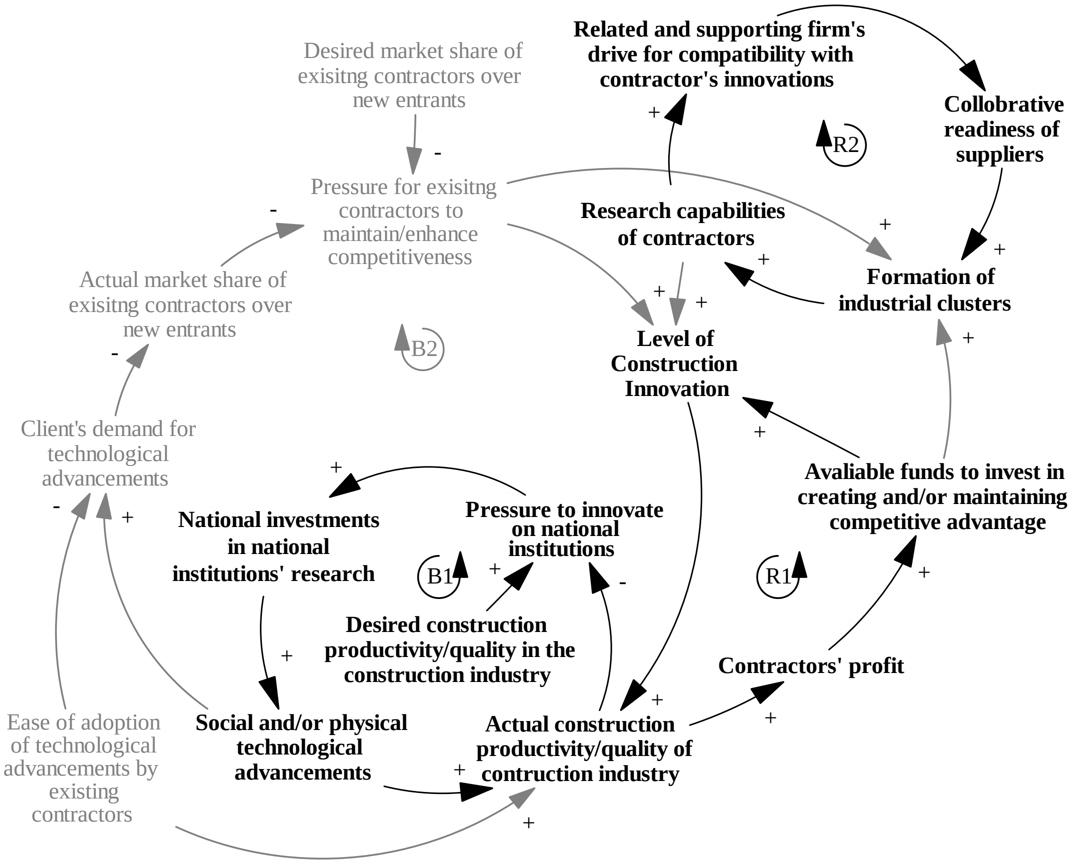

Figure 1: The NSI model for Stimulation of Construction Innovation through NSI

Consequently, it is observed that based only upon national deployment of R&D resources, it appears rather inadequate for promoting innovation in construction [19]. Furthermore, Milford observed that while the role of the government-supported research institutes and universities in the development of the construction industry is without question, the extent of their contribution or influence is difficult to quantify [20]. Hence, the question remains if technological advancements from national institutions are able to stimulate increases in the level of innovation by contractors. Expanding on the feedback loop B1 to the involvement of construction innovation (Figure 2, B2), the regression analysis presents an inverse relationship between productivity and quality, and innovation. Structuring this within the dynamic flow of feedbacks within the NSI, a fall in productivity can trigger higher pressure to innovate on the national institutions. With new technological advances developed by national institutions, clients will demand that contractors implement the new technology. This will trigger a higher level of competitiveness in the industry, as new entrants with the latest technology will enter the industry while incumbents struggle to implement these changes and/or engage in further innovation that will allow them to maintain their competitive advantage and market share. This will cause a higher level of innovation that will cause a second new wave of momentum through the cycle by influencing the level of productivity and quality. The positive relationship between the level of competition in the industry and innovation is supported by the regression results. Thus, although B2 is similar to B1 in encompassing a balancing nature, B2 differs from B1 by first, simulating innovative behaviour by firms and second, enabling the formation of industrial clusters that cultivates higher research capabilities of companies, hence, reinforcing the level of innovation by firms.

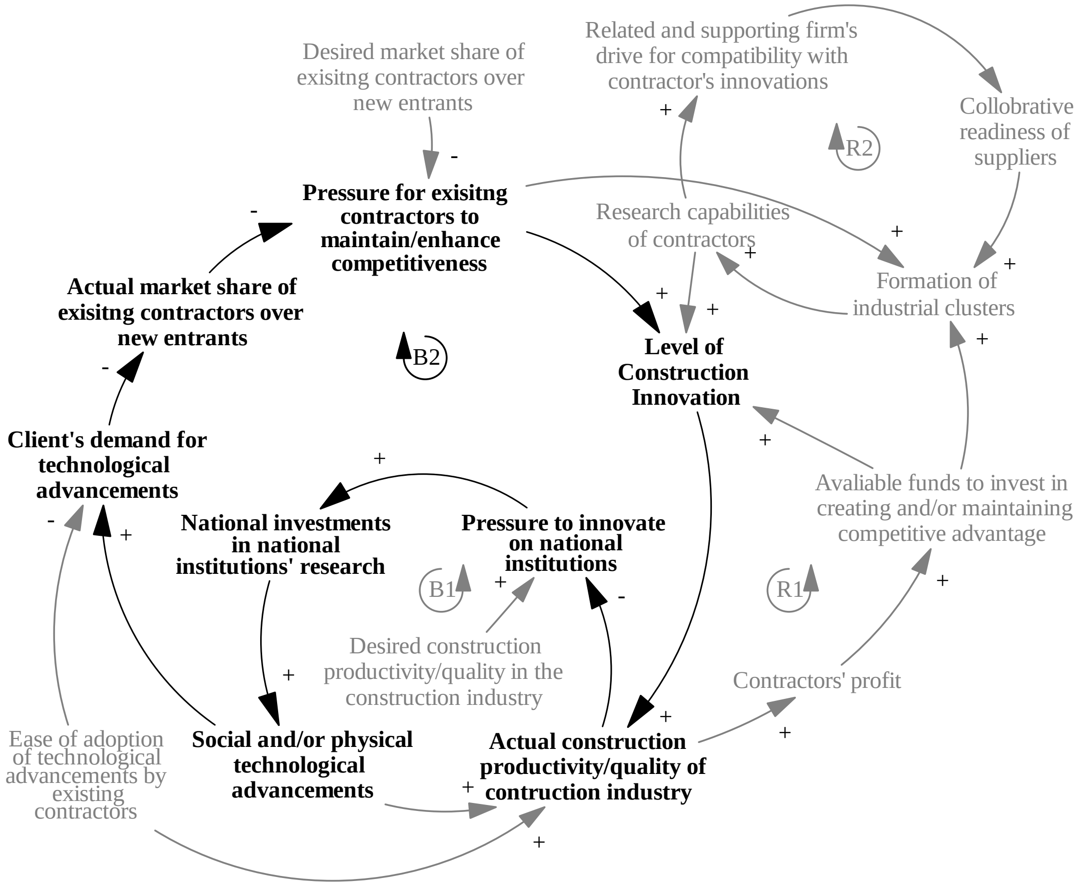

Figure 2: Stimulating Construction Innovation through a Competitive Environment

These observations offer a riposte to the belief that the level of investments in national institutes is already high and any further investments in resources will yield meagre, if any, returns and could even entail a waste of resources [7]. Clearly, even if technological advances by national institutions do not provide adequate returns through a direct increase in productivity and quality, national institutions can still play a significant role in stimulating higher levels of innovation by contractors through developing a competitive environment. However, this requires a reconfiguration of strategies and a careful choice of the type of technological advances. From the feedback and logics in the NSI model, the key variable that determines if technological advances are able to cultivate a competitive environment is the ease of adoption of new knowledge by firms. This is mainly dependent on whether the new technology involves roughly the same kind of knowledge and skills as the old. If so, firms tend to be able to switch over to it rapidly to maintain entry barriers. If not, the presence of new knowledge tends to dilute the extent to which existing firms have advantages over potential entrants and new firms tend to enter the industry [17].

3.3 Competitiveness, a Push Factor for the Formulation of Industrial Clusters

Clusters are defined as 'the geographical concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and institutions (such as universities, standards agencies and trade associations) in particular fields that compete but also cooperate' (Porter, 1998, p.199). Clusters can be seedbeds of innovation because of the potential of intellectual spillovers and agglomeration economies [7]. The Survey of Cambridge notes the difficulty of cultivating dynamic industry clusters as although government's pressure on the corporate and research sectors backed by financial incentives can create an agglomeration of establishments devoted to research, the spillover effects of such action can be slow to materialize [21].

Nonetheless, Porter notes that the underlying motivation for cluster formation is firms' ability to gain competitive advantage as through industrial clusters, firms are able to form commercially useful forms of collaborative interaction that encourage deeper inter-firm transactional engagements [18,22]. This view is reflected in the NSI model (R1, Figure 1) where the pressure for existing contractors to maintain and enhance competitiveness in the industry can lead to the formation of clusters as firms search for membership in established networks to develop their competitive base. This will increase the research capabilities of contractors that will, in turn, attract related and supporting firms as they align their compatibility with contractor's innovations. Hence, this cultivates collaborative readiness among the parties that will once again facilitate the formation of innovation clusters that further enhance firms' research capabilities. With such a reinforcing behaviour, the higher the number of clusters formed, the higher the contactors' research capabilities developed. This will eventually increase the level of innovation in the industry. This positive relationship between contractors' research capabilities and the level of innovation is supported by the regression results. Hence, the competitive environment which national institutions are capable of providing not only stimulates contractors to engage in innovation, but it also compels firms to engage in the formation of clusters that will engage in innovation as a long-term strategy.

3.4 A Financial Perspective

Although it was established earlier that there is an inverse relationship between construction innovation, and productivity and quality, the model shows that productivity and quality can also provide a reinforcing impact on the level of innovation. Figure 1, R2 indicates that higher productivity and quality will bring about higher profitability to firms. This will led to more funds being available for innovation, thus creating a higher level of innovation. This relationship is supported by the regression analysis where the higher the level of bank loans and advances to contractors the higher the level of construction innovation. Nonetheless, as the regression results show, an inverse relationship exists between innovation and the level of productivity and quality. Therefore, it can be deduced that construction productivity has a greater impact on the level of construction innovation through competition rather than the financial support.

4. Policy Recommendations

Nelson notes that empirical scholars of technological advance have always understood that the rate and character of technological advances are influenced by the institutional structures supporting it, and that institutions also strongly condition whether and how effectively new technologies are accepted and absorbed into the economic system [17]. Nonetheless, it was observed that supplementary to the effectiveness of technology transfers between national institutions and contractors, the ease of adoption and the type of technological advance provided by national institutions also determines the extent of influence national institutions can have in stimulating contractors to innovate. As Metcalfe notes, the scope for technological improvements, the likely productivity of innovative efforts and the significance of the developments in the underpinning of knowledge bases must be understood if policy is not to collapse into vague generalities [23]. Yet too often development of new knowledge by national institutions tends to lend strength to prevailing technologies that favours incumbents and that involve a direct improvement in productivity and quality rather then the stimulation of innovation.

Moreover, it was deduced that construction productivity has a greater impact on the level of innovation through competition rather than profit. Hence, direct improvements in productivity and quality has limited stimulating effect on the level of innovation. In stimulating innovation through national institutions, competitiveness offers a much better avenue. Thus, there is an increasing need for a reconfiguration of institutional strategies of nations not because increasing national resource mobilizations and investments are inadequate recipes to embrace but due to the need to recognise that the extent of latent economies of scale differs from technology to technology, and the variation in the ease of learning by incumbents is of major significance compared with providing more generally accessible sources of technological know-how.

From the analysis, to enable the creation of a competitive environment that will stimulate greater levels of innovation in the construction industry, new knowledge from national institutions should facilitate a radical shift away from old practices. For instance, in Singapore, the Housing and Development Board's (HDB) Prefabrication Technology Center (PTC) was set up in 1994 to spearhead the use of prefabrication technology in Singapore. Its main activities include conducting research and development (R&D) on materials and systems and to design, develop and produce prefabricated building products [24]. Although this industrialisation programme has enabled the local construction industry to improve productivity and quality, it has little or no stimulation effect on the level of innovation within the industry.

However as the balancing nature of the feedback in B2 indicates, competitiveness depends on the oscillating nature of social pressure that obstructs the continuous growth of innovation through competitive pressures. However, this oscillating behaviour is due to the socially desired level of productivity and quality remaining constant throughout the interaction time. In the first cycle, high levels of innovation induce improvements in actual construction quality and productivity. This leads to lower pressures to innovate as the gap between social desire and actual construction quality and productivity contracts. Hence, with a lower pressure to innovate carried over into the second cycle, the level of innovation will be lower compared to the first cycle. This leads to a lowering of the construction quality and productivity, widening the gap between socially desired and the actual, hence, causing the pressure to innovate to oscillate upwards once again into the third cycle. Therefore, to reduce the magnitude of the oscillation, social intentions must be frequently reviewed as the industry develops, to convey the right signals to firms.

5. Conclusion

To address the effectiveness of national institutions in stimulating construction innovation in Singapore, this study employs the concept of the NSI through qualitative system dynamics. A series of supporting logics that aid the analysis of national institutions' technological advancements towards stimulating greater innovation by contractors are identified. The social desire for higher productivity and quality emerged as the main driving force for technological advancements by national institutions within the NSI. From further analysis of the NSI model, it is concluded that the ease of adoption and types of technological advances provided by institutions supplement the effectiveness of technology transfers between national institutions and contractors in stimulating a higher level of innovation by contractors. However, this analysis is based on the restricted analysis of monetary investments without the consideration of other social factors such as the impact of personal mobility in the construction industry.

Nonetheless, it is shown that the system approach can assist national institutions in developing more robust and responsive policy initiatives in their choice of technological advances. In addition, the institutional structure has a profound effect on and reflects, the technologies that are in use, and which are being further developed. However, the findings from this study need to be augmented with further research such as work aimed at quantifying each variable within the NSI. Moreover, applying this NSI model quantitatively across several countries will enable the derivation of the magnitude of influence each NSI determinant has on construction innovation.

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Section III

Organisational Learning

The Influence of Social Networks on Inter-firm Exchange in Construction

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Abstract

The choice of an appropriate governance form is seen to be essential for the effectiveness and efficiency of construction projects. However, the insufficiency of legal mechanisms to govern inter-firm exchanges in construction has been perceived. Formal contractual relationships have to be complemented and even substituted by social mechanisms in order to allow an efficient cooperation among autonomous parties within an uncertain and complex environment. This conceptual paper addresses the foundation of social mechanisms and their role in coordinating and safeguarding exchanges in construction projects. As part of an ongoing research project it develops a framework that establishes the relation between the social network of construction firms and the inter-firm exchange in projects.

Keywords: Social network, social mechanisms, inter-firm exchange, project governance

1. Introduction

During the last decades the search for appropriate governance structures for construction projects has become one of the main tasks to meet the fragmented structure and adversarial nature of the industry. Particular attention has been paid to the role of contracts for the suitable allocation of liabilities and responsibilities of each project party [1, 2, 3]. It is argued that the contract is the means by which the clients define the project organisation and align their objectives with those of other parties [4] and that the relationship of project participants largely depends on the choice of a proper contracting strategy [1, 5]. The transaction paradigm of Williamson [6] is mostly used as the theoretical framework for identifying alternative contractual arrangements and explaining their efficacy in terms of avoiding claims and disputes and leading to a win-win situation. In the light of transaction cost economics, previous research has also stressed that due to the unique and uncertain nature of construction projects, formal contracts are ineluctably incomplete, leaving project parties vulnerable to opportunistic behaviour of other project participants [2, 4, 7]. The inadequacy of legal mechanisms to govern inter-firm exchange in construction has been perceived [2, 7]. Relational contracting is regarded as the basis for alternative forms of governance coordinating and safeguarding construction transactions. Formal contractual relationships have to be complemented and even substituted by non-legal or social mechanisms in order to allow an efficient cooperation among autonomous parties within an uncertain and complex environment [1, 2, 3, 5, 8]. Although the literature strongly emphasises the importance of social mechanisms for the efficacy of construction projects, little is known about how these mechanisms evolve and how they can resolve coordinating and safeguarding problems of inter-firm exchanges in construction. The social network theory advances our understanding in this regard. Since the critique of Granovetter [9] and the growing importance of inter-firm alliances, the economic behaviour of firms has been considered as socially embedded. It is postulated that the structure and the quality of all a firm's relationships shape expectations of exchange partners and create opportunities "that are difficult to replicate via markets, contracts, or vertical integration" [10]. Based on that, it can be proposed that the economic exchange in construction projects is also affected by the social network of the project participants, including the dyadic and the overall relations of these participants [11].

This paper addresses the foundation of social mechanisms governing construction transactions and their role in coordinating and safeguarding exchanges in construction projects. Its intention is to develop a framework that establishes the relation between the social network of construction firms and the inter-firm exchange in projects. Specifically, it shows that exchange conditions in construction require certain exchange behaviour of project parties to diminish transaction costs. Furthermore, the paper explains how social mechanisms may facilitate this exchange behaviour by acting as informal rules between construction firms. Finally, it demonstrates how these social mechanisms may emerge from the relational context in which the economic action of construction firms is embedded. The paper represents the conceptual part of an ongoing research project which aims to determine the role of social networks in construction and their effects on inter-firm exchanges.

2. Exchange Conditions and Exchange Behaviour

The importance of social networks for inter-firm exchanges in construction derives from specific transaction features in that industry, under which neither market nor hierarchy are efficient forms for governing the construction process. The exchange conditions of construction rather call for a cooperative engagement of autonomous firms within projects.

The dependency of the constructional task on clients and locations represents the primary condition explaining the necessity of cooperative behaviour of independent parties for construction transactions. Firstly, it results in *transaction uncertainty*, which refers to the inability of individuals and organisations to predict the probability of unexpected events during the course of transactions [6, 12]. Since in construction it is the client who triggers the planning and erecting of a building, construction firms are confronted with a fluctuating and uncontrollable demand. This is intensified by location-bound, weather-influenced activities which lead to seasonality. As a result, construction firms face long-term uncertainty about getting contracts. Although other industries also show similar kinds of environmental uncertainty, construction firms are insufficiently able to balance fluctuations through e.g. stock-keeping or creating a market for their services. Demand is the factor that directly determines the utilisation of their resources. As a response to a changing demand rate, subcontracting services increases flexibility and minimises fixed assets by reallocating resources cheaply and quickly [7, 13]. Not only long-term but also short-term contract uncertainty pushes firms towards the decoupling of services. Short-term contract uncertainty is based on binding offers for products which do not exist. Construction firms can consider the associated risks through a supplement to the quoted price, but this lowers the chance of getting the order. Passing a part of the uncertainty to other firms who might be better able to bear the risk reduces the danger of costs not covered by the bid price. Thus contract uncertainty facilitates the fragmentation of constructional tasks, the activities of which are carried out by a number of independent firms.

Dependency on clients and locations is, secondly, combined with *transaction complexity*, which refers to the number, diversity and interdependence of inputs needed to complete constructional tasks. Many construction projects not only entail a variety of components and equipment for the realisation of foundation, carcass, façade, ventilation or heating systems, but also have to process a wide range of technical, legal, environmental and organisational information. In addition, due to the different requirements of clients and locations, these inputs vary within and between projects to a certain extent. Numerous, interconnected and variable inputs lead to mutual dependency of activities which in turn boosts the need for coordination. Time pressure, a very common characteristic of construction, heightens the necessity of coordinated activities additionally, as reducing the time to complete a project requires activities carried out simultaneously [13]. Due to transaction complexity, increased management effort is required to direct decoupled activities resulting from contract uncertainty in order to achieve the overall project objectives.

Thirdly, dependency on clients and locations entails *post-contract asset specificity*, which refers "to the degree to which an asset can be redeployed to alternatives uses and by alternative users without sacrifice of productive value" [14]. Winch [8] points out that, in most cases, asset specificity has no relevance in construction before the contract is let. As firms offer services which have to be yet transformed into a building meeting the requirements of client and location, construction services tend to be exchangeable. That is, the procurement of disaggregated services based on lowest price seems to be most advantageous. However, once the contract is made, specificity arises due to the difficulty of replacing the firm without prohibitive costs [8]. A reversed situation occurs, as construction transactions themselves do not occur in a pure spot market. The costs and course of the project process rely on temporally bounded services completed on time and within budget.

It becomes obvious that construction projects have to combine two diametrically opposed organisational principles. On the one hand, contract uncertainty and pre-contract asset specificity push firms to fragment the construction process. On the other hand, transaction complexity and post-contract asset specificity intensify the need for integration and coordination of the activities to be fulfilled during the course of the construction process. Contractual arrangements are inadequately able to overcome this problem of coordinating and safeguarding transaction processes between autonomous firms, as they cannot cover each possible change of circumstances without increased costs for negotiating, drawing and enforcing the contract [2]. Legal mechanisms alone cannot prevent opportunistic behaviour and assure cooperative behaviour among project parties. Rather social mechanisms are needed to balance the competing demands of exchange conditions by “sanctioning cooperative behaviour in today’s transaction positively and sanctioning uncooperative behaviour negatively in future transactions”[15].

3. Exchange Behaviour and Social Mechanisms

If autonomous firms cooperate, they acknowledge their mutual dependence and their willingness to work for the success of the project. This implies, first of all, confidence that transaction partners will not act opportunistically. Trust is a significant characteristic of cooperative behaviour, which allows project parties to interact through the collective constitution of meaning and shared expectations about their future behaviour [16]. It provides the basis for an effective information exchange and a joint problem solving, both essential for complex and uncertain project environments. A lack of trust eliminates communication processes and leaves conflicts unsolved with destructive impacts on project outcomes. As mentioned above, under the specific conditions intrinsic to construction, contracts can absorb uncertainty and complexity of construction transactions only to a certain extent. Trust also has to be evolved “out of shared background assumptions and shared experience” [17]. Social mechanisms facilitates trust include *experiences from the past*, *expectations of the future*, *reputation* and *a common normative context* [13, 15]. They all have in common that they reduce uncertainty about the future behaviour of project partners and thus allow a more efficient interaction.

Experiences from the past refer to previous transactions between parties and are shaped by the duration, frequency and success of these transactions. Former exchanges allow firms to directly collect information about the behaviour of project partners. Granovetter [10] points out that information from one’s own past relations with an organisation is better than information from a trusted informant who is reliable. First-hand information is cheap, richer, more detailed and accurate [10]. Thus, through past experiences the behaviour of project partners becomes more predictable and, in case of a successful collaboration, more trustworthy [15]. A first indication of the effect of past experiences on inter-firm exchanges in construction was provided by Eccles [18]. In his investigation of homebuilders’ subcontracting practice, he found that general contractors built up stable relationships with specialised subcontractors and that this repeated exchange was in conjunction with lower use of formal bidding and contracting [18]. Similarly, Zaghloul and Hartman [3] found that the willingness of clients and contractors to use a different method of risk allocation regarding disclaimer clauses increases with the previous working experiences the contracting parties have with each other.

Expectations of the future refer to forthcoming transactions between parties and are shaped by the assumed significance of these future transactions. This means that the possibility of future exchanges between same project parties influences the current behaviour of these parties. If anticipated gains of future transactions outweigh short-term benefits from cheating in the present, cooperative behaviour is more likely. It is suggested that violating an ongoing agreement decreases the probability of cooperation in the future, whereas cooperation during the current transaction can also bring on cooperative behaviour during the next exchange [19]. However, future transactions have to be sufficiently important to make opportunism unproductive. The chance to interact again and the relevance of coming exchanges have to be large enough to promote cooperative behaviour through reciprocity [19]. One can argue that expectations of the future play a minor role in construction, since the necessity of allocating different resources for each constructional task leads to changing organisational constellations. However, Constantino et al. [5] suggest that business relationships between contractor and subcontractor differ in various construction sectors. They investigated commercial contractors and compared them to the homebuilding sector by referring to the aforementioned study of Eccles [9]. Their results revealed that the market extent in terms of geographical spreading differs between homebuilders and commercial contractors. Homebuilders operate in a geographically limited area that reduces the possible choices or substitutions of specialised services, which in turn leads to good working relationships. Commercial contractors show a lower tendency to durable relationships with subcontracting firms, as they are active in a larger geographical area. This can be seen as an indicator for the effect expectations of the future have on construction transactions. Because of the chance of repeated exchanges, the likelihood of cooperative behaviour in regionally restricted markets increases.

Reputation refers to the expected behaviour of persons or organisations based on information about or observations of its past behaviour. It is bestowed upon by others and reduces uncertainty as it allows a firm to know something about the reliability, capability and goodwill of potential transaction partners [13]. Analogous to expectations of the future, the value of reputation evolves from reciprocity. Cooperative behaviour in the present can induce cooperation in the future through recommendations of third parties. Likewise, opportunism can prevent cooperation in coming transactions due to warnings of the same parties [15]. Winch [8] points out that reputation is of paramount importance in construction, since "(f)or a professional firm to lose its reputation for consummate project execution is a serious, and sometimes fatal, penalty" [8]. However, as mentioned earlier, first-hand information is preferable. Due to the diffusion across several organisations, information about reputation may be inaccurate, misinterpreted or give a false colour [13].

A common normative context refers to shared assumptions and values of a group of persons or organisations which guide activities of and create typical behaviour patterns among members of these groups [13]. It coordinates the interaction of autonomous parties by generating convergence of expectations and establishing an idiosyncratic language [6]. These generically understood rules, being valid for a range of transactions, facilitate cooperative behaviour. A common normative context also defines and reinforces the parameters of acceptable behaviour, the violating of which can lead to collective sanctions [13]. An indication for the influence of cultural issues on cooperative behaviour in construction projects is mostly provided through the negative effects the absence of a common normative context has. Particularly the strong affiliation to a professional or organisational group seems to shape the attitude of project parties to each other. It is argued that the similarity of persons allows the maintenance of a self-image, which in turn prompts these persons to treat others belonging to the same group more favourably than persons from other groups [7, 20]. More generally, it may take a long time to establish a common understanding among autonomous project parties.

Although several studies contain references to the impact of social mechanisms on exchange behaviour in construction projects, theoretical and empirical knowledge about how they may facilitate the coordination of construction transactions is scarce. Moreover, until now little has been known about the foundation of social mechanisms in construction. Thus, the following paragraph will shed light on the role of social networks in this regard.

4. Social Mechanisms and Social Networks

A social network can be defined as a specific set of relations among a defined group of persons or organisations, the characteristics of which may be used to interpret the social behaviour of the persons or organisations involved [21]. Thus, social networks in construction include dyadic and overall relations of clients, contractors, subcontractors or suppliers. It is argued that the social network comprises the context in which economic activities occur and that the social relations affect transactions, their outcomes and the behaviour of transaction partners [10]. The project-based nature of construction – construction exchanges are conducted within projects - suggests three types of social networks: *project-dependent networks*, *cross-project networks* and *project-independent networks*.

The project-dependent network comprises all temporary relations among persons or organisations involved in realising the constructional task in a project. Through project-dependent networks the actual inter-firm exchange in construction takes place. Due to the dependency of constructional tasks on clients and locations, the interaction of project parties to complete the transactions and to ensure their efficiency requires, to a certain extent, the evolvement of alternative governance mechanisms. Thus, through project-dependent networks, the social context in which transactions are embedded is activated. In doing so, social mechanisms are not only applied but, simultaneously, reinforced or diluted. Interacting in projects also enhances the likelihood of mutual contacts, experiences and diffused information which future transactions may refer to. Particularly reputation and experiences from the past strongly depend on the current behaviour. Based on that, the extent to which cooperative behaviour is prevalent in project-dependent networks may be seen as an indicator for the existence of social mechanisms. The more trustful relations among project parties exist and the better the communication and problem-solving techniques are, the more it is likely that social mechanisms govern the ongoing transactions.

The cross-project network includes all recurrent relations among persons or organisations that go beyond single projects and span a series of constructional tasks. They may arise consciously through joint agreements or are due to regionally restricted or specialised markets. In all cases the number of possible exchange partners is reduced, which leads to repeated transactions between the same parties. Cross-project networks create one part of the social context which is capitalised through project-dependent networks. Particularly experiences from the past and expectations of the future are founded in the linkages of projects the same parties are involved in. Continued interactions may permit transaction partners to learn from each other, to develop common working routines and to reduce the amount of monitoring activities. Moreover, repeated exchanges may increase the commitment among parties, allowing the achievement of individual and joint goals. Finally, intensive and intended long-term cross-project relations may establish a common normative context which renders the behaviour of network firms more reliable and predictable. Given this, it can be argued that frequency, duration and success of repeated transactions determine the degree to which social mechanisms contribute to cooperative behaviour in construction projects. However, until now there has been a lack of empirical research that substantiates the link between variables of repeated transactions and social mechanisms. For example, it is still ambiguous to which extent project constellations differ and, thus, influence the role social mechanisms play for transaction governance. A strong change in constituting projects seems to inhibit the evolvement of a social context, whereas a moderate movement among firms may tie different groups together and may activate reputation through circulating information. Furthermore, there is little evidence whether the activation of social mechanisms requires the allocation of the same persons in project teams.

The project-independent network contains all permanent relations among persons and organisations that are built up besides the transactions necessary to realise constructional tasks. It generates the other part of the social context project-dependent networks make use of. Project-independent networks may evolve through the participation of persons or firms in social, trade, professional or other voluntary organisations [22]. This participation allows information about third parties to be collected and spread across organisational boundaries, which in turn may lead to valuable reputation. It can be expected that the more project parties are connected through project-independent networks, the more information each party knows about the other parties and the more a party's behaviour can be sanctioned. Participation in voluntary organisations may also lead to the development of a common normative context. On the one hand, similar preferences and values can emerge. On the other hand, professional organisations in particular provide guidelines which regulate the practice of their members by specifying roles, procedures and accepted solutions to problems. It can also be assumed that the membership of project parties in project-independent networks fosters collective knowledge, shared sense-making and understanding among these parties [23]. Similar to cross-project networks, little is known about the importance of personal relationships in contrast to organisational membership with respect to the effect of social mechanisms.

5. Conclusions

There is an ongoing discussion in theory and practice about the possibilities and ways for more collaborative relations in construction or alternative forms of project governance. It is proposed that a closer relationship between firms is beneficial to the overall performance of the industry. However, Dubois and Gadde [23] conclude that modifications of the current relational pattern may reduce some uncertainties and increase others. They describe the construction industry as a combination of tight couplings in projects and loose couplings in the permanent network of firms. On the one hand, loose couplings complicate coordination by preventing inter-firm adaptations to complexity and uncertainty. On the other hand, loose couplings provide slack and flexibility to handle tight couplings in projects. Dubois and Gadde [23] emphasise that the combination of tight couplings in projects and loose couplings in the permanent network appears to be appropriate in terms of project efficiency but less favourable in terms of learning and innovation. It is obvious that for finding an appropriate governance form, the mechanisms coordinating and safeguarding construction transactions have to be considered. Besides contractual arrangements, social mechanisms appear to be indispensable to ensure the effectiveness and efficiency of construction projects.

This paper highlighted the role of social mechanisms for inter-firm exchange in construction and the foundation of these informal rules in the social network of project parties. It developed a framework which deepens the understanding about the efficacy of the social context for transactions in construction. As part of an ongoing research project, the framework depicts the starting point for the forthcoming empirical investigation. The investigation focuses on medium-sized contractors (50-100 employees). The choice was made on the assumption that this type of firm mostly operates regionally, which increases the possibility for recurrent transactions with other project parties. Additionally, personal relationships seem to be particularly beneficial to these firms, as executives are formative for the firms.

The empirical study is divided into two parts. The first part includes semi-structured interviews with the top management of medium-sized contractors. The aim is to put the relations of the framework into a more concrete form and to make them operational. The second part consists of a questionnaire survey aiming to give a broader support for the previous findings. At the conclusion of the research project a more detailed picture about social networks and their influence on inter-firm exchange in construction should be obtained.

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Social Networks and Organisational Learning in Construction

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Abstract

This paper discusses the facilitating role of social networks in trans-organisational learning in the construction industry. A qualitative learning model is used to illustrate how knowledge diffuses from an individual to the industry. Social networks are classified as intra- or inter-organisational. Empirical research based on 395 questionnaire responses received in the Hong Kong construction industry shows that knowledge transfer in intra-organisational social networks is stronger than that in inter-organisational social networks. Learning activities such as knowledge-sharing workshops are recommended to exploit hidden organisation's knowledge created by social network learning, which should be a valuable asset that organisations and their members own in common.

Keywords: construction, information, knowledge transfer, organisational learning, social network

1. Introduction

Information is permeable across construction organisations, given the openness of organisational boundaries. Organisational-barrier-free information exchange reflects the spontaneous nature of organisational learning as noted by Nelson and Winter [1], Levitt and March [2], Huber [3] and Glynn et al [4]. Social networks play an influential role in spontaneous organisational learning by forming the major channel for boundless human interaction across organisations [5]. Organisation's knowledge created in such a way is of social, community-based nature [6], and most likely a raw, valuable asset that organisations and their members own in common [7]. Departing from a theoretical consideration that spontaneous organisational learning is ineluctable organisational behaviour, this paper first discusses the facilitating role of social networks in trans-organisational learning in the construction industry by modelling a ripple effect stemming from individual learning. The empirical work that follows compares potentials of intra- and inter-organisational social network learning using a data sample collected in the Hong Kong construction industry.

2. Spontaneity of Organisational Learning

Organisation's knowledge originates from organisation members. Organisational learning denotes a process over which knowledge of organisation members is shared, developed further by interaction, and then transmitted throughout the organisation. Organisational learning of this nature is partially emergent, relatively unplanned and inspired by some incidental processes [8]. A distinct feature of such emergent organisational learning is spontaneity. In other words, learning is not intentional.

Although many construction organisations have recognised the need for learning as observed by Jashapara [9], it seems that the concept of intentional organisational learning has yet to root firmly in the strategic minds of many construction executives, as revealed by Kululanga et al [10]. This paradox should not negate learning construction organisations, however. In practice, spontaneous organisational learning in the construction industry is common.

As Nelson and Winter [1], Levitt and March [2], Huber [3] and Glynn et al [4] point out, organisational learning may have no intent. Organisational learning loosely denotes learning with or without intent. Perhaps all organisations are learning. The only difference should be the presence of learning intent. The positive relationship between organisational learning and competitiveness accruing as a result of improvements in actions [11] or organisational performance [12] should be the prime strategic issue of learning with intent. Learning intent would influence the organisation's outputs, experience and knowledge. Organisational learning of this nature is planned organisational learning, which is intentional and formally planned [8]. Organisational learning should be considered as a two-layered learning system. The outer layer is coated with learning intent. The inner layer is made of spontaneous texture, which is the primary focal point of this research.

3. Organisational Learning as an Open System

Spontaneous organisational learning is osmotic, given that organisations are not closed systems. There are influxes and leakage of knowledge in organisational learning. Very often knowledge would drain out from or enter organisational learning as a result of inter-organisational interaction through, for example, strategic alliances, joint venture projects, inter-firm staff rotations, subcontracting and mergers.

Inter-organisational human interaction highlights the openness of organisational learning. People working for different organisations would contact one another beyond the organisational boundary. Social networks are major channels facilitating boundless human interaction across construction organisations [5]. Organisational learning considered here is practical. It takes the role of social networks into account. Organisations being the agent of organisational learning at issue allow the penetration of knowledge. Knowledge is absorbed from the external environment, and refined in the organisation. Such refined knowledge will then be exported to the external environment.

4. Social Networks

Social networks can be regarded as a social relationship among actors, who can be people, groups, organisations, communities or even society [13]. As Brown and Duguid [14] point out, social networks linking actors for common practices or knowledge domains facilitate rapid dissemination and assimilation of knowledge in common. The role of social network in learning should originate from its cognitive context. It holds that people keep social relationships to secure mutual support of their interpretations of issues and events, which are important but ambiguous [15]. Focusing on their use in learning, Fu et al [5] consider social networks as individual networks of friends and acquaintances; practitioners thereby can earn other network members' support in dealing with problems encountered at work [16]. For concise discussion purposes, the terms 'social network' and 'social learning network' are considered synonymous in this paper.

Trustworthy behaviour, which coheres with friendship, is a significant trait of social networks. As Liebeskind et al [17] point out, social networks crystallise shared norms of trustworthy behaviour, based on which practitioners can exchange information. Friendship is not merely a social context embedded in inter-organisational ties for quality information exchange [18, 19, 20, 21]. Rather, friendship contains both sentimental and instrumental elements [22], which collectively bring forth routine reciprocity of nominations [23]. By linking people working in the same field of work, friendship lubricates social network learning. Learning takes place when people share knowledge with those who are appropriate, helpful and reliable.

5. Intra- and Inter-Organisational Social Networks

Intra- and Inter-organisational social learning networks are emergent products of intra- and inter-organisational interaction. Inter-firm staff rotations contribute greatly to the formation of inter-organisational social networks. Organisation members not only develop social networks with present colleagues, but also keep friendly contact with former colleagues. This situation occurs concurrently among organisations. It can be seen that not only inter-organisational social networks are intertwined, but also many inter-organisational social networks are extensions of intra-organisational ones.

Knowledge transfer needs networks channelling useful information. Interpersonal ties constitute the structure of social networks for use in this respect. According to Podolny and Page [24], interpersonal ties are interpreted as a nexus of relationships between two or more individuals who keep contact for recurring and enduring exchange. Given the organisational boundary, two independent types of interpersonal tie are identified. They are the organisational tie and the embedded tie. These two types of interpersonal tie constitute a distinct feature differentiating inter-organisational social networks from intra-organisational social networks. The structure of inter-organisational social networks contains no organisational ties, whereas intra-organisational social networks are a hybrid structure of organisational and embedded ties.

The organisational tie refers to the structure of organisation members' networks for work. It exists within the organisational boundary. Organisational ties are formed mainly based on the colleague-relationship. Organisational ties substantially remove physical barriers to face-to-face communication. As a traditional medium of intra-organisational communication style [25], face-to-face communication is useful to knowledge transfer because of the tacit nature of knowledge. In face-to-face communication, organisational members can share knowledge with words, supplemented with graphics or even gestures. Interpersonal contact proceeding of this hybrid nature can enhance the effectiveness of knowledge transfer, especially when the topic of discussion cannot completely be verbalised.

The embedded tie refers to the structure of communication and friendship networks. It exists within or beyond the organisational boundary. With no organisational governance, friendship is the major context of embedded ties. Embedded ties facilitate the transfer of fine-grained information, the growth of trust, joint problem-solving arrangements [19, 26], all of which enable and enrich social network learning.

6. Social Networks Bridging Organisational Learning to Collective Learning

Social networks connect organisational learning to collective learning. Knowledge transfer by interaction recognising the influential role of social networks is depicted in Figure 1. Four levels of learning are identified according to the institutional structure of the construction industry as follows: individual learning (of organisation members); organisational learning; inter-organisational learning (between organisations in various fields of business in a construction sector); and collective learning (between all construction organisations, in particular stakeholders including the government, educational institutions, professional bodies and trade unions).

Individual learning works as a process of continuous, incremental modification of the current behavioural mode to improve the quality of recurring action responding to a set of given situations recurring with high similarities. A datum is the element of information, moving at large in the external environment. In the words of Corner et al [27], information is 'potentially meaningful data that deserve attention'. Interpretation denotes a process of organising data in a particular context [28]. Data are assigned with meanings by interpretation. Individual learning is endowed with adaptive behaviour as a continuous data interpreting process over which useful data are retained but useless data are discarded [29]. Knowledge is loosely considered as useful interpreted data. An interpreted datum is defined as the elemental unit of knowledge.

Knowledge transfer is simply considered here as the dissemination of interpreted data. It proceeds as a dyadic interaction between two learning agents: the knowledge provider and the knowledge receiver. As depicted, the four levels of learning meet at a common point, which is also the centre of individual learning. An interpreted datum stems from an organisation member (a knowledge provider). Organisational boundaries are permeable, as denoted by non-solid lines. Knowledge moves freely over different learning levels. This responds to a prior research assumption that organisational learning is an open system. A ripple effect of knowledge transfer departs from this common point. Knowledge may be transferred to knowledge receivers at any one of the learning levels or both via social networks. A few scenarios of learning are given as follows. When the knowledge receiver is a colleague, organisational learning will stem. When the knowledge receiver is a friend working for another firm, inter-organisational learning will take place. When the knowledge receiver is a friendly practitioner working together for a committee in a professional institution, collective learning will begin.

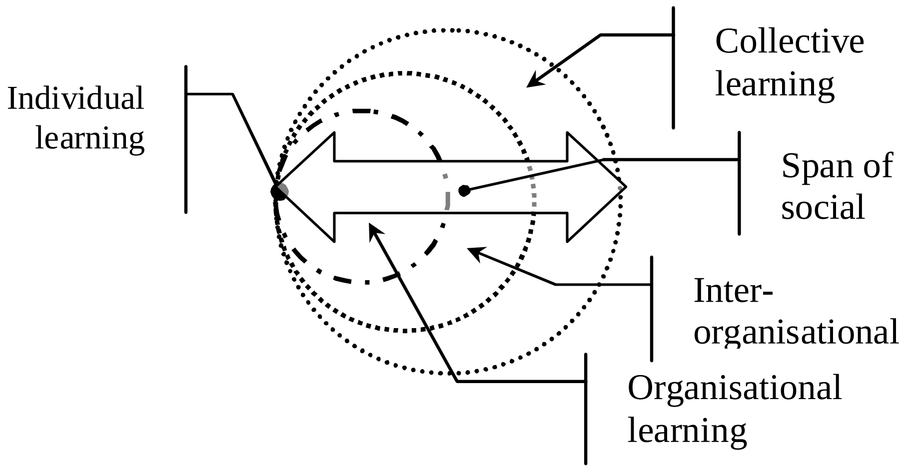

Figure 1: Knowledge transfer by social networks in construction

7. Effect of Intra- and Inter-Organisational Social Networks on Knowledge Transfer

Intra-organisational social networks are made of organisational and embedded ties, whereas inter-organisational social networks specific to the present research are solely made of embedded ties. Given that embedded ties exist in both inter- and intra-organisational social networks, it is argued that the frequency of face-to-face communication, which is technically called the 'intensity' of social networks [13], is an overwhelming factor accounting for disparities of the speed of knowledge transfer.

The rationale for this argument is practical. When an individual encounters a problem at work, colleagues he/she knows should be the preferred people from whom useful advice may be sought. This is understandable in two aspects. First, responses from colleagues are convenient and quick. Friendly practitioners who can offer the same advice working in another office may not be immediately reached. Second, discussion in an office can keep a common focus on the object turning the problem up. For instance, a design engineer is disturbed by a problem of construction details. Face-to-face communication between colleagues keeping a common focus on drawings in this instance is effective interpersonal contact. Frequent contact at work empowers knowledge transfer by providing people with more opportunities of face-to-face communication.

8. Empirical Evidence

The empirical work reported below aims to justify the research hypothesis that knowledge transfer in intra-organisational social networks is stronger than that in inter-organisational social networks.

Empirical data were collected through a questionnaire survey conducted in the Hong Kong construction industry from May 2003 to March 2004. Questionnaires were distributed to practitioners by the use of the authors' social networks in the industry. Friendly practitioners of the authors were first requested to answer the questionnaire and forward it to their friendly practitioners, who are actors at the second level of the authors' social networks. Those friendly practitioners at farther levels of the authors' social networks were requested to do so. This referral method produces a ripple effect in data collection. Finally, a sample comprising 395 (N) valid responses received from practitioners in 17 fields of professions and technical work having on average 10 years of work experience in the construction industry is used for empirical analysis.

In the survey, respondents were requested to express their attitudes towards the dissemination of a lesson learned (expressed as a failure case experienced by another practitioner in the questionnaire) in their social networks. The question reads as follows:

Suppose that one of your friends or acquaintances, who also works in the construction industry, tells you a failure case (including the background and the consequence) that is largely a technical mistake of a practitioner. Will you tell this story to others whom you know?

Respondents were requested to answer the question in respect of the following five categories of people 'whom they know':

1. Superiors (S);

2. Colleagues very familiar to (Cvft);

3. Colleagues fairly familiar to (Cfft);

4. Colleagues not familiar to (Cnft); and

5. Friends, but not present colleagues (F).

Respondents have seven choices of equal-appearing intervals in the form of a Likert scale in answering this question. The score is arranged in ascending order in relation to the magnitude of the descriptive choices. 'Extremely unlikely' scores '1'; 'Very unlikely' then scores '2', and so on until 'Extremely likely' scores '7'.

Results of the survey show that Cvft and F are the top two categories of people to whom respondents are willing to convey the lesson learned. Cvft and F are representative categories of actors of intra- and inter-organisational social networks, respectively. Survey results of these two categories can provide empirical evidence to justify the research hypothesis.

Differences between scores for Cvft and F are compared. A score difference (S_{Cvft-F}) is simply the net difference between scores for Cvft (S_{Cvft}) and F (S_F) given respectively by a respondent. Then,

$$S_{Cvft-F} = S_{Cvft} - S_F \tag{1}$$

An S_{Cvft-F} obtained by Eq. 1 ranges from –6 to 6. An S_{Cvft-F} value of 6 indicates that a respondent would be 'extremely likely' to tell a friendly colleague (Cvft) the lesson learned, but 'extremely unlikely' to do so when the knowledge receiver is a friend (F). An S_{Cvft-F} value of –6 is a reverse indication of an S_{Cvft-F} value of 6.

The frequency distribution of S_{Cvft-F} values is shown in Figure 2. Results of the S_{Cvft-F} distribution indicate that many respondents prefer Cvft to F in disseminating the lesson learned. The range ($0 < S_{Cvft-F} \leq 6$) is regarded as the Cvft-preferred Region, which indicates respondents' preference for Cvft. 219 positive S_{Cvft-F} values are observed. They represent 55.4% of *N*. It is about 7 times larger than the corresponding percentage of another range ($–6 \leq S_{Cvft-F} < 0$), which, representing 8.1% of *N*, indicates respondents' preference for F (regarded as the F-preferred Region).

Summary statistics of score differences are shown in Table 1. Statistical inference proceeds to check if paired-differences in S_{Cvft-F} observations are statistically significant. Now the null hypothesis is that the population mean of S_{Cvft} is equal to or smaller than that of S_F. The alternative hypothesis is that the population mean of S_{Cvft} is greater than that of S_F. The *t* test statistic 14.042 (d.f.=394, *p*=0.000) is significant at the 1% level. The null hypothesis should be rejected. It is concluded that the population mean of S_{Cvft} is significantly greater than that of S_F. These empirical observations provide evidence supporting the research hypothesis.

Table 1: Summary statistics of S_{Cvf} , S_F and S_{Cvft-F}

	N	Mean	SD
S_{Cvft}	395	5.660	1.081
S_F	395	4.635	1.454
S_{Cvft-F}	395	1.025	1.451

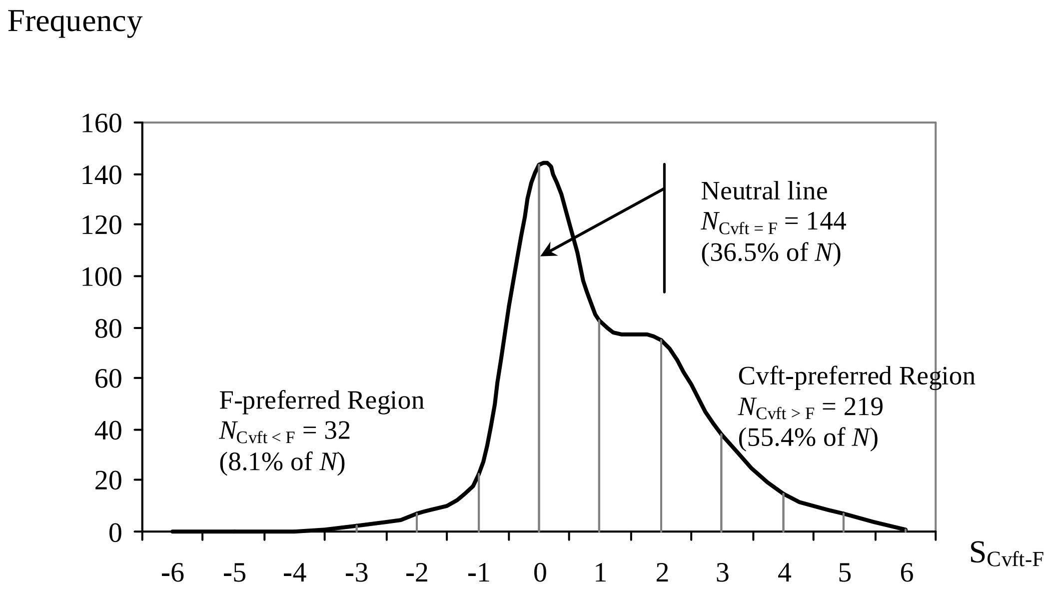

Figure 2: Score differences between Cvft and F (N=395)

9. Conclusions

Social networks bridge organisational learning to collective learning by facilitating organisational-barrier-free knowledge transfer. Intra-organisational social networks will emerge when the organisational structure is coated with a social context. Inter-organisational social networks this paper speaks of are largely extensions of intra-organisational social networks, resulting from inter-firm staff rotations. The questionnaire survey provides empirical evidence showing that knowledge transfer in intra-organisational social networks is relatively stronger. This finding highlights the value of hidden organisation's knowledge created by social network learning. Knowledge embedded in organisational members' social networks will definitely be a source of competitive advantage if it can be fully exploited. Learning facilitators are recommended to institutionalise social network learning by, for example, organising regular in-house workshops to provide organisation members with ample knowledge-sharing opportunities.

Acknowledgements

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A Case-based Reasoning Model as an Organizational Learning Tool

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Abstract

Organizational learning (OL) is a set of activities to obtain organizational memory (OM) by acquiring, sharing, interpreting, integrating and institutionalizing knowledge. Although the OL process of construction firms has been discussed for several times, utilization of the output of these activities has not been investigated in depth. All companies can learn but the advantage of learning is revealed when companies enhance their decision-making abilities through their OM.

The major objective of this study is to explore how construction companies create OM and how they exploit this asset in strategic decision-making process. Within the context of this research, a framework is constructed to model the OL process in a construction company and based on this model; an interview study has been conducted with eight leading Turkish contractors.

This survey revealed the strengths and weaknesses of the firms in terms of OL competence. The most significant point is that although some perceptions and attitudes are common to all companies, some may change due to the differences in cultures, strategies, structures, ages of companies and the markets they are in. Results show that construction companies make use of several knowledge sources and mechanisms to acquire knowledge; they are successful at the collection and storage of knowledge but they are weak in exploitation of the corporate knowledge in strategic decision-making stage. In addition, they are unable to increase their OL competence due to some company and industry specific barriers. One of the key outputs is that companies are not familiar with the decision support systems (DSSs) that benefit from OM. Such systems enable OL by assisting decision-makers in processing, assessing, integrating and organizing knowledge.

In this paper, a case-based reasoning (CBR) model is proposed as an OL enabler and to facilitate decision-making in international market entry decisions within the construction companies. This tool is generated under a software package by adopting CBR as the problem solving approach, which finds solutions to new problems making use of the past experiences which are based on 215 cases from the Turkish construction industry. The model produces two outputs that are indicators of attractiveness of a project and competitiveness of a company,

which are the key decision criteria in an international market entry problem. The application of the tool will be demonstrated by a case study and potential benefits of using the proposed model as an enabler of OL in a construction company will be discussed.

Keywords: Knowledge management, organizational memory, decision support systems, case-based reasoning

1. Introduction

Strategic management of knowledge requires intuiting, interpreting, integrating and institutionalizing of knowledge flows [1] which take place at individual, group and organization levels respectively. Formation of an organizational memory (OM) is a critical knowledge management activity which facilitates organizational learning (OL) process. Stein and Zwass [2] define OM as the means by which knowledge from the past is brought to bear on present activities, thus it helps learning from previous experiences. OM becomes a corporate asset by capturing, organizing, disseminating and reusing the knowledge created by its employees [3].

This paper is based on the findings of a research study carried out to investigate how construction companies create their OM and how they exploit this corporate asset in strategic decision-making. The OM formation process has been modeled considering that the companies mainly learn from their own experiences, from the experiences of competitors and from external sources [4]. Knowledge gained through different sources are shared, interpreted and institutionalized to create OM. Based on this model, a semi-structured interview form has been prepared and interviews have been conducted with 8 leading contractors in Turkey.

Findings of this study reveal that construction companies are successful at acquiring knowledge but they are weak in sharing and utilizing the acquired knowledge in decision-making. Although companies need the tools to support their strategic decisions, they are not familiar with this kind of systems. As a result of the interview findings, a knowledge-based system is decided to be developed to support international market selection, for which the companies necessitate a tool to assist their decision at most. A CBR-based decision support system (DSS) has been developed, which facilitates learning from experiences of competitors in international markets.

2. Organizational Memory in Construction Companies

Since the construction industry is project-based, discontinuous and fragmented, OL is difficult for the companies. For this reason, as well as the systematic knowledge management activities, construction firms should also provide a culture that can facilitate continuous learning in order to benefit from the advantages brought by OL. A successful culture of OL can influence performance, long-term effectiveness and survival of an organization [5, 6]. Lehner and Maier [7] stress the function of OM in connecting past and present decision-making situations that directly influences the performance of a company.

Robey et al. [8] define OL as an intentional and unintentional organizational process, which enables the acquisition of, access to and revision of OM and finally guides to organizational action. Using the logic behind this definition, an OM framework is constructed [4]. Figure 1 illustrates how OM is formed, utilized during decision-making and finally revised. Although companies create OM as a result of the learning practices, the advantage of possessing such an asset should be revealed in the quality of the strategic decisions made in the company.

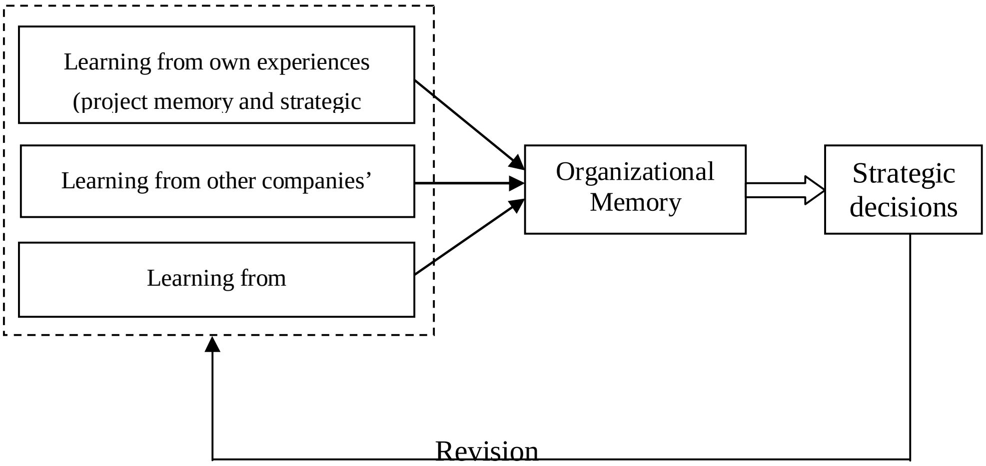

Figure 1 Framework explaining the OM formation and utilization

The three components that constitute OM are own experiences of the company, experiences of other companies and knowledge gathered from external sources. OM is used to improve strategic decisions and after the actions are taken, new experiences are added to OM. This is a cyclic process rather than a sequential process as newly acquired knowledge from the given decisions should be used to revise OM. How this cycle operates in each company depends on company characteristics and the height of OL barriers.

3. Research Study

Semi-structured interviews are carried out by company professionals in order to highlight the realities of the Turkish construction industry in terms of OM. 8 companies volunteered to participate in the research. The structure of this interview study is demonstrated in Figure 2. Questions are grouped under eight headings, one of which is the company information and other seven topics are related to the knowledge management practices are discussed below.

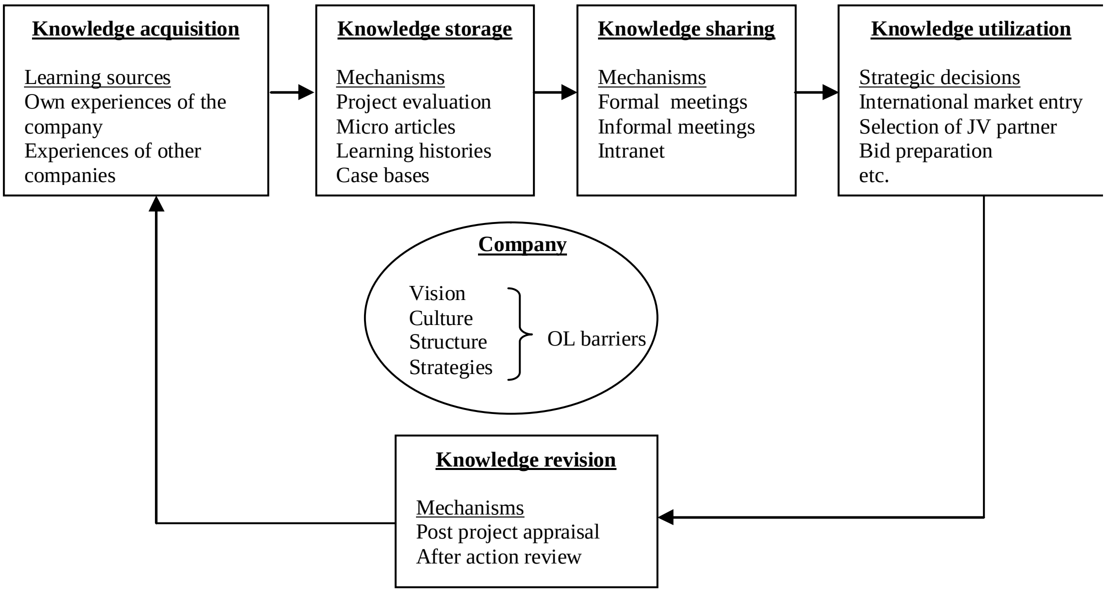

Figure 2 Structure of the interview

1. Learning from own experiences: Lessons learnt from own experiences of the company can be examined under two categories; the knowledge gained from the projects, namely the project memory and the knowledge gained from strategic decisions. These two sources shall be improved as more projects are carried out and more strategic decisions are made. Since the unit of work performed in the construction industry is project, companies mainly learn from the projects they have undertaken and parties involved in these projects. Knowledge may well be acquired as a result of "unrealised projects" where the experiences related with bidding, business development, financial management activities etc. are of paramount importance. Companies do not only learn from the completed projects but also from the ones that companies intend to perform but are not awarded. In this respect companies are asked to state which kind of data they collect and how they store information within their organizations.

2. Learning from other companies' experiences: Construction companies may learn from success/failure stories of their competitors or if they establish long-term or short-term (project-based) partnerships with other companies such as clients, contractors, suppliers etc., they may learn from their practices, expertise and perceptions. Also, relevant expertise of companies operating in sectors other than construction may be transferred to the construction business.

3. Learning from external resources: External learning sources are the parties, which are not directly involved in the projects that construction companies perform, or not among the parties they cooperate or compete with. The company managers are given a list of possible external learning resources such as universities, consultancy firms, governmental or foreign bodies that are not clients, etc. and they are asked to state from which resources they learn.

4. Organizational memory: While individual knowledge is an important part of OM, it is always at risk of being lost. Knowledge acquired through the learning sources have two types, namely explicit (codified) and tacit. Explicit knowledge can be accessed by company members easily since it becomes a corporate asset by being stored in computers in the form of electronic repositories or it is documented in paper form. The tacit knowledge is hidden in the beliefs, perceptions, norms and actions of individuals and requires to be transferred to explicit knowledge in order to be stored. Under this heading, there exist questions regarding the contribution of different learning sources to the company's memory and the percent distribution of knowledge types according to how they are accumulated in the company.

5. Utilization of OM in strategic decision-making: Due to the unique nature of each construction process, inherent uncertainties and incomplete scope definition, it is almost impossible to have all the needed information at the time of decision-making and mostly decision problems are solved by expert judgment. Entering an international market, entering a new market related/unrelated to construction sector, selection of JV partners, preparation of bids and restructuring of the company are among some of the critical strategic decisions made by companies. To facilitate decision-making, DSS, which combine analytical methods with expert opinion, are proposed to be utilized. In this study, it is argued that OM is a valuable asset that must be built and exploited in order to give more reliable decisions at the corporate level and enhancing the codified component of the memory will aid strategic decision-making with a DSS. The research sample is asked to evaluate the importance/effectiveness and utilization level of OM and DSS during decision-making.

6. Organizational learning competence: A company is assumed to have high OL competence if it is good at benefiting from knowledge acquisition sources, if it has knowledge storage mechanisms, if this knowledge is shared and interpreted by the company members, if the end product of these knowledge management activities, namely the OM can be effectively utilized in decision-making process and if the company can continuously revise its OM. Companies are evaluated in terms of the learning practices performed within their organizations.

7. Organizational learning barriers: Although OL is accepted to be necessary and critical concept for the survival of the companies, due to some reasons, OM creation is not at the desired level in most firms. In literature some authors mention the existence of some enablers and barriers to capture and diffuse knowledge such as structure effects, cultural context, the climate for change, skills and capabilities, technological mechanisms and objectives. To find out the dominant barriers to OL, the company managers are asked to list why they are not fully performing the requirements of OL and the causes of deficiencies to structure the OM.

4. Research Findings

Important conclusions can be derived from the answers of the respondent companies, which are extensively discussed in Ozorhon et al. [9]. The most significant point is that although some perceptions and attitudes are common to all companies, some may change due to the differences in cultures, strategies, structures, ages of companies and the markets they are operating in.

Findings of this study reveal that construction companies are rather good at creation of project memory. Experiences gained by the company as a result of previously realized construction projects constitute the major component of OM. The experiences of other companies have a limited contribution to OM, although all respondents agree that learning from failure and success stories of other companies is of paramount importance for construction companies. This kind of information usually resides in the brains of experts, but it is rarely stored in databases and institutionalized.

Companies think that the role of OM in strategic decision-making is limited. Intuition and experience usually play a far more significant role when giving bidding decisions, entering a new market or making new investments. All respondents agree on the importance and use of the codified component of OM in order to build mathematical models especially in bid preparation. Companies do not utilize DSS to aid them in decision-making in spite of the fact that they believe it would be beneficial to have such programs. However, answers of the respondents demonstrate that especially for international market entry decisions, assistance of a computer program would be very beneficial.

When the knowledge management activities are considered, in general, companies seem to be most successful at acquiring and revising knowledge. Knowledge sharing is the most important activity, which is followed by the utilisation of knowledge in decision-making however, these activities are not usually performed as successful as they are regarded to be important.

Some OL barriers related with the nature of the construction industry and service/product exist as well as company-related factors such as cultural barriers. Although perceptions about validity of learning barriers change significantly from one company to another, high employee turnover in construction and corporate management/leadership style seem to be common problems that plug the way of OL in construction companies.

5. CBR as an Organizational Learning Tool

In the experience-based construction industry, previously acquired knowledge is critical to solve similar problems that can be encountered in the future. Although the output of construction is a unique project, construction processes show similar characteristics. As CBR is an analogical learning technique, it seems to be a suitable approach to solve construction problems, which are generally solved through past experience and knowledge of expert people.

CBR is “the process of solving new problems by adapting solutions that were used to solve old problems” [10]. Indeed, CBR uses the principles of human reasoning as it learns from the past situations. With this feature, CBR can be applied in problems that can be solved through previous experiences. CBR solves problems through a process that involves some basic steps as retrieving relevant cases from the case memory, selecting a set of best cases, deriving a solution, evaluating the solution and storing the newly solved case in the case memory [11].

Due to the project based nature of the construction industry and high employee turnover rates, knowledge becomes hard to capture and store. Thus, construction companies should build case libraries that will enhance OL and create OM. These case libraries enlarge OM by institutionalizing the individual knowledge. On the other hand, CBR-based models enable this knowledge to be shared and utilized in the strategic decision-making process. So, development of CBR-based strategic DSS is proposed to increase the OL capability of the companies.

6. CBR-INT

International market selection is a complex decision as numerous factors related with the country, market and project have to be considered and there is no mathematical formulation that can easily associate these factors together with company specific factors with the attractiveness of a project and probability of getting the job given the competitive conditions. There are models developed by many researchers on this subject using different techniques such as cross impact analysis [12], analytical hierarchy process [13] and neural networks [14]. Case-based reasoning (CBR), which exploits past experiences to bring solutions to new situations, has been identified as a promising tool.

The system, as an enabler of OL, is generated under a software package namely, ESTEEM that adopts CBR principles to solve the problems. Experiences of Turkish contractors are used to demonstrate how experiences of competitors may be utilized to facilitate decision-making in a construction company. The model, CBR-INT is developed by using 215 real international project data; 200 cases are used for training the program and 15 cases are used for testing purposes. As input information, 16 features related with the project, market and the country are identified and by the help of CBR-INT, as important indicators, the attractiveness value of an international project and the competitiveness value of a company for that project can be predicted (Figure 3).

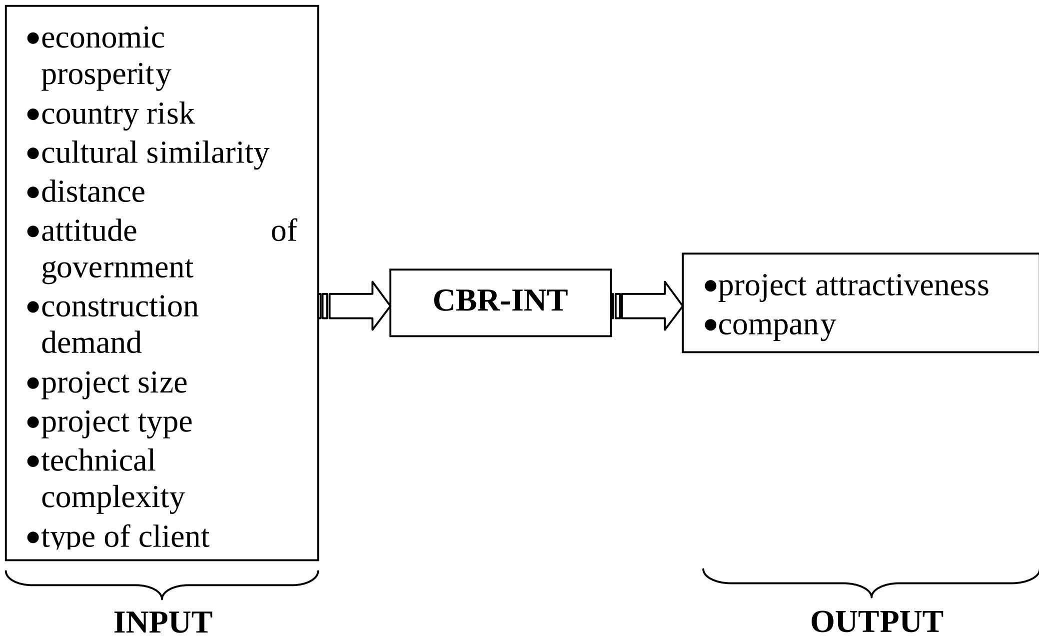

Figure 3 Modeling of CBR-INT

The system adopts both manual and weight generation methods for similarity assessment and retrieves similar cases in the order of their similarity scores to the target case. Adaptation is carried out with different manual methods that will help final prediction. After trying several adaptation models, the best one is selected based on the performance values. The reliability of the best model is found to be around 90%. The case library can be enriched by the incorporation of the latest cases and a larger case library can be used for the retrieval step for the solution of the next problem.

An experienced and large company in Turkey was asked to provide the data of a real international project in order to test the applicability and performance of CBR-INT. The target case was an infrastructure project that requires high experience and where there exists very high competition. The user, business development manager, was requested to specify the values of input parameters; then CBR-INT is run to predict the attractiveness and competitiveness values. Figure 4 presents the retrieved cases list on which similarity scores, case names and corresponding values appear.

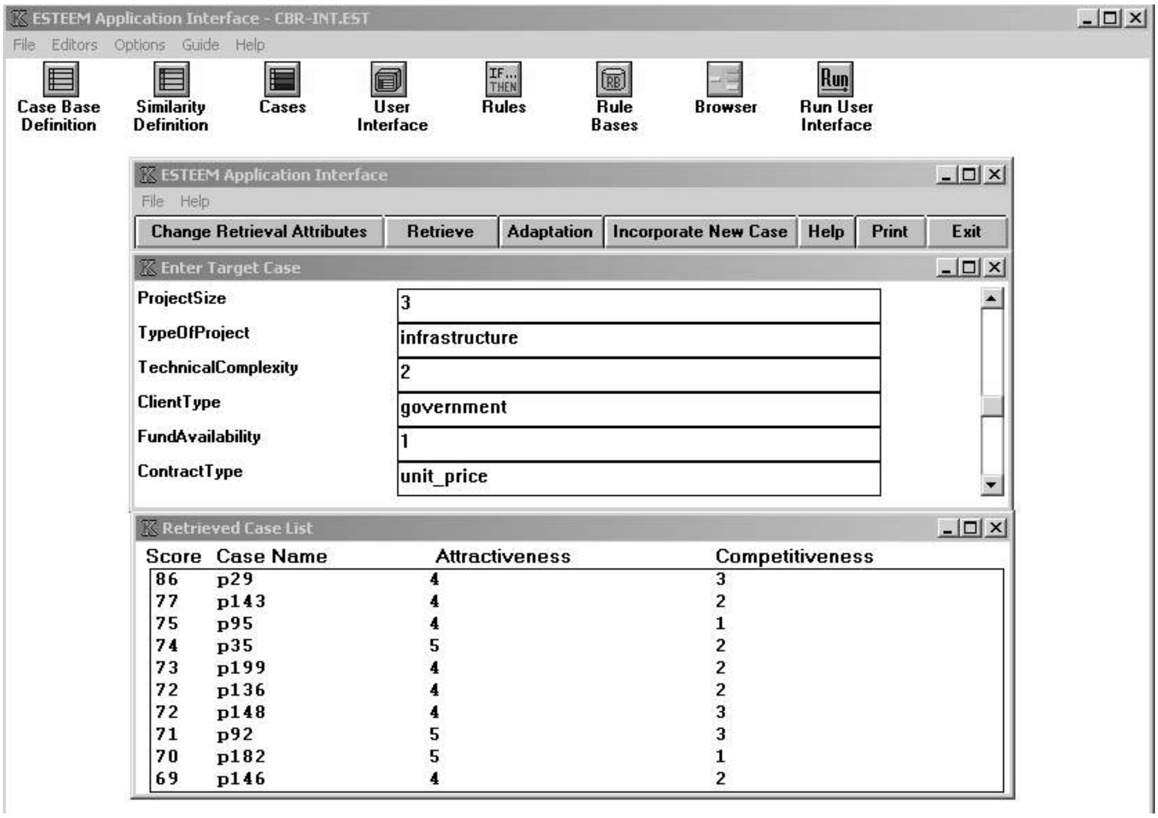

Figure 4 An application of CBR-INT: Retrieval of similar cases

At the end of the application, the project seemed to be highly attractive but the competitiveness value of the company was medium. This situation was expected because the company was meeting the requirements to perform the job but the threat of the competitors was almost impossible to avoid. When the results of the system and the real decision given by the business development manager are compared, it is observed that the model had produced exactly the same conclusions as an expert would do. The manager also was highly satisfied with the performance of the system as it is easy to use and it increases confidence about given decisions.

7. Conclusions

One of the main concerns of this study is to find out how construction companies create OM and how they utilize this asset during strategic decision-making. In the context of this paper, the framework representing the OM formation and utilization is presented; the interview study prepared using this framework is discussed; some of the research findings are summarized and a DSS, which was developed to aid construction companies in international market entry decisions is introduced.

Answers of the respondents denote that construction companies learn from several sources; they are very good at acquiring and storing knowledge but they cannot share knowledge among employees widely. Almost all respondent companies learn mainly from their own experiences;

learning from other companies' experiences and external resources have less contribution to the OM within the companies.

When the knowledge management activities are reviewed, it is seen that companies are most successful at acquiring and revising knowledge. However, they believe that knowledge sharing and utilization of knowledge in decision-making are the most important two activities, which should be carried out in the construction companies, but they are rather weak in these activities. One of the main barriers of OL is the high employee turnover rate that prevents companies embed knowledge within the organization. The other important factor is the firm infrastructure and culture that determine the effectiveness of the learning environment.

One of the most significant points is that the role of OM in strategic decision-making is limited for the construction companies. Company managers usually do not refer to codified knowledge in OM or utilize DSS; rather, they make strategic decisions based on their intuition, experience and expertise. Construction companies especially need a decision support tool for international market entry as found from the interview study. In order to meet the requirements of the industry, a CBR-based DSS is developed.

CBR has become a promising technique in the construction management field due to its ability to reason from the past that well suits to the construction problems. Since in construction industry, decisions are made through experience, construction problems cannot be modeled by strict rules; CBR is a promising technique to aid decision-making in construction business.

The proposed system namely, CBR-INT, is used to predict project attractiveness and company competitiveness when giving bid/no bid decisions in international markets. The reliability of CBR-INT is proved to be high for both prediction of attractiveness and competitiveness and its applicability is shown by a real case taken from the Turkish construction industry. CBR-INT is an example that demonstrates how DSS may increase the OL competence of companies since it requires the acquisition of several data, interpretation of data, transferring it into information, storing in a database and utilization of knowledge at the decision-making stage. CBR is proved to be a promising technique which may increase utilization rate of OM during decision-making and CBR-based DSS may facilitate OL in construction companies.

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Use of Feedback System in Traditional Contractual Approach

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Abstract

There is a separation between design and construction functions in a construction process and is even more in traditional approach. Thus, to exploit construction knowledge and experience in order to learn from the past to improve constructability of the design, some change seems to be required in the current practice. Early involvement of the constructor in the design process is also viewed as a contributing factor for more efficiency and productivity. Since experience is considered as a valuable asset in the area of construction, this paper discusses the concept of learning organization, a feed back system developed for traditional contractual approach to improve constructability and comments and suggestions made by professional engineers on the practical applicability of the feedback system.

Keywords: Learning organization, constructability, feedback system, traditional contractual approach.

1. Introduction

1.1 Background

One of the major drawbacks of the division of design and construction in most of the contracts is said to be that those who do not have sufficient construction experience carryout designs. Many construction problems are said to have resulted from the division of design and construction process. In the absence of learning from past experience, similar types of problems in similar types of constructions will be repeated.

Therefore, experience is considered as a valuable asset in the area of construction. The analysis of organizational learning showed that there are two levels of learning-lower and higher level takes place in an organization (or in a process). So far as the construction process is concerned, it is different from those types of organizations (or processes) where under a single umbrella different major activities take place or different departments function. In construction process, there is two major phases function under two different settings and the phases more or less follow one after the other. A designer (design firm) carries out design function and a contractor (construction company) carries out construction function. This is more apparent in traditional contractual approach.

The underlying principles of organizational learning will help organizations, wherever they are, in acquiring and transferring experience and knowledge and in modifying their behaviors accordingly. In construction, the separation of design and construction process is criticized for many problems encountered during construction. The importance of organizational learning, thus, is that it encourages to look beyond owns organizational walls for ideas and support. Nima et al rightly say, “ Now the construction industry has a great need to implement constructability due to the size and complexity of projects and to the fragmentation of the construction field into specialized roles and expertise.” [1] The objective of this paper is to propose the feedback system for traditional contractual approach for implementation.

1.2 Methodology

The concept of learning organization and constructability were discussed in the classroom with the students of M. Sc. in Construction Management in the year 2003 and 2004. After discussions, they were provided with the open questionnaire along with the feedback model. The contents of the comments obtained from the respondents were analyzed and discussed in this paper. Among 60 questionnaires distributed 49 (81.66 %) returned back. The design and construction experience of the respondents are shown in table 1.

Table 1: Design and Construction Experience of the Respondents

Experience (Years)	**Design Experience (Number)**	**Construction Experience (Number)**
< 5	31	13
6 – 10	6	17
11 – 15	9	12
> 16	3	7
Total	**49**	**49**

2. Learning Organization

Cangelosi and Dill made a pioneering study of organizational learning in 1965. [2] Since then, many writers have contributed in this area by their influential writings. However, after the publication of The Fifth Discipline, The Art and Practice of Learning Organization written by P. M. Senge in 1990, this concept has been widely accepted. However, no theory or model of organizational learning has been widely accepted.

The earliest definition of organizational learning was that of Herbert Simon who defined organizational learning as the growing insight and restructuring of organizational problems by individuals reflected in the structural elements and outcomes of the organization itself. [3] In this definition, Simon has insisted on growing insight, structural elements and outcomes of the organization. Chris Argyris viewed organizational learning as a process of detecting and correcting error. [4] Error, according to him, is any feature of knowledge or knowing that inhibits learning. He emphasized on organizational response to changes both in the internal and external environment.

Friedlander added the importance of past experience in the process of learning. [5] According to him, system should be geared in such a way that organization made authentic contact with the past. Role of past experience in learning as an agent for change was supported by Robbins who described learning as any relatively permanent change in behavior that occurs as a result of experience. [6] Levitt and March also highlighted the link between past experience and learning. [7] In the same way, Stata said that organizational learning occurs through shared insights, knowledge, and mental models and builds on past knowledge and experience for which he called "memory"[8].

Peter Senge, who popularized the notion of learning organizations, have defined it as an "organizations where people continually expand their capacity to create the results they truly desire, where collective aspiration is set free, and where people are continually learning how to learn together."[9] Highlighting the usage of acquired information Pareek has defined organizational learning as the process of acquiring, retaining, and using inputs for its development. [10]

From the definitions put forwarded by the scholars, most of them are found viewing organizational learning as a process of acquiring and using those acquired knowledge in the form of "learning" (from past experience) in order to improve the performance. This basic and fundamental ground of learning organization is also seems equally important to the construction industry, because, experience is considered as a valuable asset in construction. The fragmented nature of construction process will also be benefited from the discussions of learning organization because notion of learning organization, in general, sought for integration of the whole processes for operating under single system.

2.1 Levels of Organizational Learning

It is observed that learning in organization takes place in two levels and generally referred to as higher level learning and lower level learning. Lower-level learning, in general, occurs within a prescribed activity or behavior. Argyris and Schon referred to lower level learning as "single loop learning". [11] They further described that single loop learning occurs when errors are detected and corrected within a given set of rules.

Lower level learning in construction process is found established in current practices. Figure 1 shows the lower as well as the higher level learning in construction process. [12]

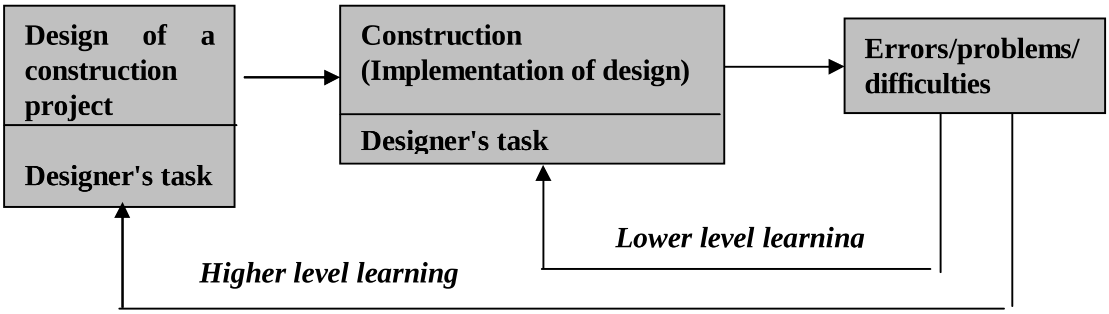

Figure 1: Levels of learning in construction process

It is also observed that higher level learning in construction process is essential to learn form past experience and to improve constructability of design.

2.2 Constructability

As described in the Constructability and Constructability White Paper, constructability is the capability of being constructed. [13] The Construction Industry Institute (CII) has defined constructability as the optimum use of construction knowledge and experience in planning, engineering, procurement and field operations to achieve overall objectives. [14] The Project Management Specialization of the University of Calgary, Canada has tried to define constructability as determining the most effective construction method prior to detailed design. [15]

From the above definitions, it is observed that the basic concept underlying in all definitions of constructability is that the appreciation of construction knowledge and experience into planning and design of a project will be beneficial.

3. Feedback System [16]

Retaining the fundamental features of the traditional approach for design and construction of a project, feedback system has been proposed so that the system can be adopted easily in practice without much disturbing the existing practice and also hoped that the professional without resistance can easily adopt the concept. It is to be mentioned here that along with the soci-economic development of the country, existing practice always required to be improved. In this regard improvement has been viewed as a continuous process. Figure 2 shows the proposed feedback system. In the existing phases of a construction process, some additions have been made to provide the feedback system for designers so that the constructability of design can be improved.

3.1 Pre-bid and Constructability (PAC) Review meeting

Pre-bid and constructability review meeting is one of the major additions in the existing phases of a construction project. In most of the large contracts, after publication of notice for tender and before bidding, a meeting called “pre-bid” meeting is arranged for the bidders (contractors) to orient them about the project. Here, it is proposed to arrange the pre-bid meeting as an equally important phase of a construction process in the form of “Pre-bid and Constructability Review (PAC) Meeting”. This meeting takes place after preliminary design and will be participated by the designer(s), probable bidders (or, pre-qualified bidders), and constructability participant (sometimes may be more than one depending upon the nature and size of the project). In this meeting contractors are provided brief of the project and the design philosophy; and the contractors are also asked to comment on the overall design, drawings, and specifications based on their construction knowledge and experience. Similarly, a constructability participant also provides his/her input to improve the constructability of the design based on his past knowledge and experience. This PAC meeting helps injecting constructor’s site know how into design and also the designer’s have the opportunity of understanding the possible consequences of his/her design during construction. “Combining the effort among designers and builders at the initial stage of design, in a co-operative manner, should reduce problems during the construction phase. Reducing problems during the construction phase reduces a project’s final completion cost. The co-operative combining of skills and experience in a conscious effort to reduce potential construction problems has been referred to as constructability.”[17] Ritz also agreed on that the design is reviewed for the application of the best construction technology to minimize field costs. [18]

Contractors’ pre-qualification (PQ), which is in practice, helps in identifying the real probable bidders (contractors). If PQ of contractors is not possible, only yearly short-listing of contractors by the functional departments also help identifying probable bidders. To invite appropriate contractors in PAC meeting, Contractors’ Associations involvement and help could also be taken.

It is to be mentioned here that the constructability participant may include one or more than one participants depending upon the nature and size of the project and that the constructability participant may not necessarily be a person who is required to be paid highly.

3.2 Finalization of Design

Finalization of design is the other phase added to incorporate the comments and suggestions obtained from PAC meeting. All the contract documents including the design are to be finalized at this stage.

3.3 Detail Project Review and a "Lessons Learned" File

After completion of the project a detail project review is proposed. This review examines in detail strengths and weaknesses of the project implementation and maintains a data file of constructability "lessons learned". This file is proposed to be kept by the owner (if the owner is a public department), the consulting firm (a designer) and the construction firm (a contractor) so that it can be retrieved for use in future constructability analysis. This detail review will also be an important feedback for both the consulting company and the contracting company. "A simple format to report valuable "lessons learned" is essential to any constructability program. Two or three paragraphs are usually sufficient to describe the reasoning and methodology of a constructability application and its results."[19]

One possible option for the improvement of the constructability is to appoint the same designers (consulting firm) for construction supervision, which was involved in the design. This helps providing real feedback to the designer so that constructability of the design can be improved. However, individual learning does not guarantee organizational learning as well as involving same consultant for both design and construction supervision, in all cases, may not be appropriate.

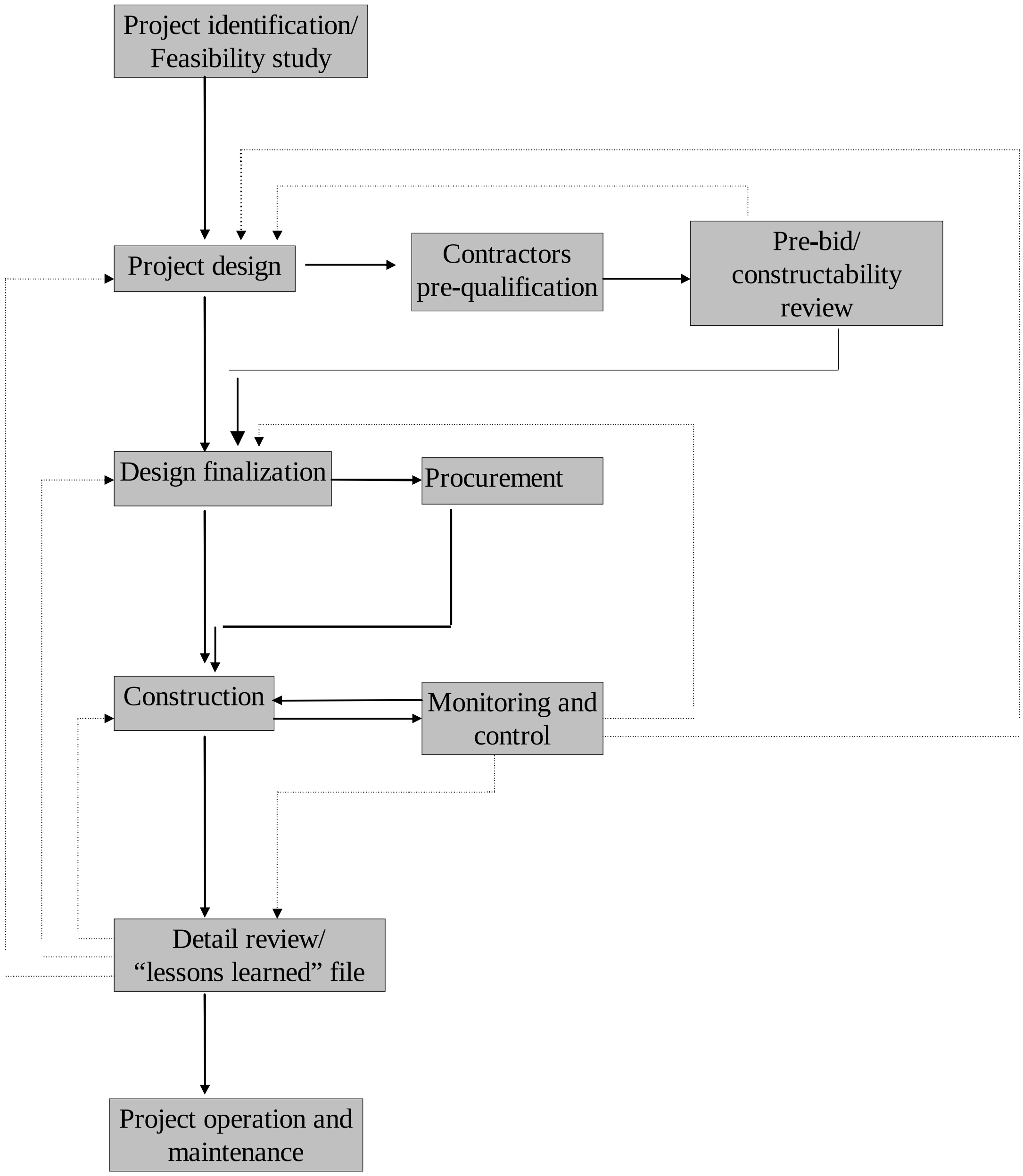

Figure 2: Feedback systems for traditional contractual approach [20]

4. Content Analysis

This section provides discussions based on the information provided by the respondents.

4.1 Applicability of the Model

In the question regarding applicability of the model the comments received were as follows:

i. The model is very effective

ii. The model is not suitable for small projects, and

iii. All the constructability participants may not be interested in attending the PAC review meeting

4.2 Impact on Time

This has been the general comment regarding impact on time – incorporation of pre-bid and constructability review meeting and finalization of design will consume more time. The respondents were of opinion that the constructability review helps in reducing the construction period. However, according to the respondents, design finalization may take time. Therefore, care should be given (a) in the selection of appropriate constructability review participant and (b) in creating the environment in which designer's should not try to defend his/her ego.

4.3 Improvement in Constructability of Design

All the respondents confirmed that this model would bring improvement in constructability of design.

4.4 Problems and Difficulties in the Model

As per the respondents' views, followings may be the problems/difficulties associated with the model:

i. All pre-qualified or short-listed contractors may not be interested in studying and commenting the design.

ii. Constructability review meeting may become a formality only due to lack of incentive to the contractor(s) participating in the constructability meeting.

It seems here that separate study should be conducted to design the incentive schemes for the contractor(s) to confirm their active and creative participation in the PAC review meeting.

4.5 What Should Be Done to Implement the Model?

The respondents said that for implementation, the model should be incorporated in the bidding document and information should be given through notice inviting tenders.

5. Conclusion

Traditional contractual approach is widely in use particularly for public construction works. Main drawbacks of this approach is the separation of design and construction process and because of this separation, separate designer and constructor involved in design and construction of a project respectively. Realizing this fact, a feedback system has been developed and proposed. For effective implementation of this model, the model is proposed to incorporate in the bidding document and information of this should be given through notice inviting tenders and the future research may be directed towards designing incentive schemes to the contractors participating in the PAC review meeting for their active and creative participation.

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MBA in Construction

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Abstract

The paper presents the results of research carried out in 1989 and 2003. Based on answers obtained from respondents, the plan and programme of international postgraduate course entitled "Business Management in Construction Industry" was formulated, as initiated by the Faculty of Civil Engineering, University of Zagreb. The plan and programme of studies are presented, and the interdisciplinary nature of the studies is explained. Preconditions for enrolment of the first generation of students were created thanks to EU financial assistance through the TEMPUS programme.

Keywords: Construction industry, business management, manager, management, survey, graduate studies

1. Introduction

Croatian civil engineers have headed large-scale projects that require special managerial abilities for many years. Although without any formal managerial training, they manage companies and projects with the goal of achieving excellent business results through the direct control of labour and of the flow of considerable financial assets.

At the Symposium of Construction Organisation in Cavtat in 1989 we presented the results of a survey [1] designed to show the most important knowledge and abilities that the good construction manager must possess, in the opinion of the respondents (civil engineers who graduated from the Faculty of Civil Engineering at Zagreb University in the period 1955-1985).

An analysis of the answers gave a rank list from which we single out the 10 most important knowledge and abilities/skills needed by the successful construction manager at that time:

1. command of the technical knowledge and professional skills,

2. responsibility towards the company and towards work,

3. ability to organise and coordinate work,

4. ability to establish good interpersonal relations,
5. ability to contract work,
6. ability to ensure quality work,
7. ability to forecast,
8. knowledge of economic business analysis,
9. ability of personnel management,
10. ability of cost control.

The respondents considered it by far the most important for the construction manager at that time to be in complete command of technical knowledge and professional skills. They firmly expressed the view that to be a good construction manager a person must in the first place be a good engineer. It is interesting, however, that they placed the ability to control expenses last of the 10 most necessary abilities.

On the other hand H. Fayol [3], the father of modern management theory, speaking generally about the knowledge necessary for managerial work, as early as 1949, established that there is a fundamental difference in the necessary scope of professional/technical and general (economic, sociological, managerial and other) knowledge for various job positions in the management hierarchy. (Table1)

Table 1. Correlation between technical and other knowledge at the work place

Work place	Technical knowledge needed	Other knowledge needed
1. Worker	85 %	15%
2. Skilled worker	60 %	40 %
3. Technical manager	30 %	70 %
4. General manager	10 %	90 %

This shows that the participation of "general knowledge" grows as we climb up the managerial ladder. Every manager well knows that the higher his position in the managerial structure, the less he has "to do" with solving professional problems and the more time and energy he spends in solving "all the other" problems in the work of the company.

Many years have passed since our first survey. The social and economic system has changed, most companies are now privately owned, and it was to be expected that views about the necessary knowledge and abilities for managers had changed as well. The very different conditions and work processes did in fact change the attitude to the knowledge and abilities/skills needed by managers. Many more people now realise that additional training is necessary for managers and it has become usual for experts, people with university degrees, to go to “schools for managers”.

In Europe and other developed countries, engineers have been systematically trained in management for years, being aware that educating and training engineers in business management and project management in construction is of great importance for the success of both - projects and companies.

At the Faculty of Civil Engineering at Zagreb University we have for many years been thinking about the need to organise a managerial course specially “designed” and adapted to the specific needs of construction. However, before making the final decision and definitely launching the new project, we wanted to find out how much the views of engineers have really changed about the need to gain new, additional managerial knowledge, so we carried out a new survey in 2003. (Appendix 1)

2. Research Results

We can perhaps most simply define the concept of manager by saying what the person who runs the company or the project must do. For example, the manager:

- is responsible for the successful realisation of many tasks, which demands the coordination of a large number of factors and people,
- focuses on the entire company but also on people individually,
- often makes decisions without complete information and under conditions of uncertainty,
- guides the work of others so as to achieve the planned goals of the company,
- depends on the work results of others,
- his/hers own work results are assessed according to the company’s business results.

Therefore most important task facing the management of every company is obviously to tailor work conditions so that the company can achieve its planned goals. For the company this usually means to ensure conditions for a safe and “normal” life on the increasingly demanding and merciless market. A good manager can save a bad company, whereas an incompetent manager can ruin a good company. This has happened many times.

Bearing in mind all the above, we wanted to define the most important knowledge and abilities needed by the “perfect manager” today, on the basis of the experiences of actual managers.

We sent our questionnaire to about one hundred e-mail addresses to find out what knowledge and abilities/skills the “perfect manager” needs today. Within one month, which was the time at our disposal, we received 55 answers (the questionnaire was sent to managers of various professions who had graduated from the faculties of economics, civil engineering, electrical engineering, mechanical engineering and naval architecture, mining, geology and petroleum engineering, philosophy, natural sciences and mathematics, veterinary medicine, architecture etc.).

We must say that our results are not completely scientific because the sample of respondents was not representative. The questionnaire included only those who are Internet users. However, we received interesting results which we will show in the continuation of this paper.

An analysis of the answers [3] gave a rank list of the most important knowledge and abilities/skills needed by the successful manager.

The results showed that today’s respondents consider knowledge in management science (by this we mean: making business decisions, organisational behaviour, designing organisation, managing human potentials, business strategy, negotiating etc.) first and foremost for the success of managers. Of the 55 respondents, 96% consider this kind of knowledge very important (41) or important (11), which places it in first place of our rank list of necessary knowledge:

1. knowledge in management science,
2. knowledge in project management,
3. knowledge in economics,
4. knowledge of foreign languages,
5. Knowledge in specific professional fields.

Knowledge about project management methods (planning methods, resource management, risk analysis etc.) was ranked second by 91% of the respondents. They placed knowledge in economics third, which includes accounting, marketing, funding, international economic relations etc.

It is interesting that has been a change in the order of the most important kinds of knowledge, although the results from 1989 and from 2003 cannot be compared completely, there.

In 1989 command of professional knowledge was ranked first among the most important knowledge and abilities, while today only 11 respondents consider professional knowledge very important, and 30 consider it important, so this kind of knowledge has fallen to fifth place on the rank list.

The reason for this may be changed social and economic conditions, and also the fact that this questionnaire included managers who had graduated from other faculties, not only civil engineers.

It is also interesting that today 85% of the respondents consider it very important for the "perfect manager" to know foreign languages. In the earlier survey, knowledge of foreign languages was 13^{th} on the list of the most important knowledge and abilities.

We also asked respondents about the necessary "abilities/skills" that the good manager must successfully master.

All the respondents (55 or 100%) consider that the "perfect manager"

- must be capable of making decisions,
- must know how to coordinate tasks and people,
- must have organisational skills ,
- must be responsible.

If we observe the category of *very important* only, then decision-making skills come first again because 81% of the respondents consider them very important. Furthermore, 41 respondents or 74% consider coordinating tasks and people very important.

In comparison with the 1989 survey, the ranking of important skills has not changed as much as the ranking of knowledge because then too responsibility and organisation and coordination skills were very highly placed on the list.

These results did not come as a great surprise because we surveyed managers, people who are very well aware of the kind of problems and challenges they meet in their everyday work.

On the basis of the results which, we must honestly admit, only fortified our conviction that we were on the right path, we continued with our efforts to launch our international postgraduate programme *MBA in Construction.*

3. MBA in Construction Course Programme

Specialisation in business management, also known as MBA (Master of Business Administration), is today the most highly respected qualification in the business world. It is a form of additional highest education in management, because the programme provides knowledge and skills that enable course participants to master business processes more easily, and to adapt to globalisation processes more quickly and painlessly. The traditional MBA programme approaches business management as an independent discipline that can be applied to all industries.

In the last ten years or so many business schools and graduate MBA study courses have been opened in Croatia. Nevertheless, we find that studies which train “general managers” cannot be easily “used” for construction managers because they do not take account of the specific characteristics of the construction process.

Construction differs fundamentally from all other industries, because in the usual industrial process the product changes its place and the factors of production (people and machinery) are static. In construction it is the opposite – the product (the facility under construction) is static and does not change its place, when the “production process” is finished it stays where it was made, while the factors of production (people and machinery) move on to the next location – to the “next product”.

This is why we launched the project of multidisciplinary and interdisciplinary MBA studies for construction managers (civil engineers, architects and kindred technical professions).

MBA in Construction is a programme that focuses on construction with the purpose of providing present and future construction managers with knowledge in various scientific and professional fields, necessary for understanding and mastering complex management processes.

Civil engineers are trained as managers in only three universities in Europe, at MBA in Construction and Real Estate by Distance Learning, The University of Reading, and Executive MBA Construction Project Management, University of Leeds, in Great Britain, and IT Based Construction Management at the Istanbul Technical University in Turkey.

Comparing their curriculum with ours we found no significant differences and our programme is completely comparable with European trends, which was confirmed when the EU assigned us financial support through the TEMPUS programme for the first generation of students enrolled in February 2003. Teaching was organised in cycles of five workdays a month for four months during a term at the Faculty of Civil Engineering in Zagreb and at the Centre of Advanced Academic Studies, in Dubrovnik.

The MBA in Construction programme is a project of Zagreb University (Faculty of Civil Engineering and Faculty of Economics), in cooperation with partner institutions from Great Britain and Germany.

In June 2003 the Zagreb University Senate approved this programme making it one of the few graduate business management programmes that has University evaluation and is recognised as an international university postgraduate course.

Thanks to TEMPUS support, teachers from British universities (Dundee University, Reading University and Salford University) and from the Technische Universität München take part in almost every subject. The programme carries a total of 120 ECTS credits in three semesters of teaching and a master's thesis, as shown below.

Table 2. The MBA in Construction course programme according the ECTS credit system

1. Semester	**Lectures (hours)**	**Seminars (hours)**	**ECTS credits**
101 Business Statistics	40		7
102 Organisational Design	40		7
103 Organizational Behaviour	40		7
104 Marketing Strategy in Construction	30		6
105 Business Ethics	20		
192 Optional course - seminar		20	3
Total ECTS credits			**30**
2. Semester			
201 Managerial Accounting	40		7
202 Construction Project Planning and Control	25		4
203 Financial Management	35		6
204 Human Resource Management	35		6
205 Negotiation and Business protocol	25		4
292 Optional course - seminar		20	3
Total ECTS credits			**30**
3. Semester			
301 Decision Theory	40		7
302 Business strategy	40		7
303 Construction Contract Law	25		4
304 Construction Project Management	30		5
391 Optional course	25		4
392 Optional course - seminar		20	3
Total ECTS credits			**30**
Optional Courses			
521 Information Systems	25		4
522 International Marketing	25		4
4. Semester			
401 Master of Science Thesis	240		3
Total ECTS credits			**120**

The subjects can be classed in three groups:

- general business management (making business decisions, organisational behaviour and organisation design, business strategy, negotiating and business protocol, business ethics)

- economic subjects (business statistics, marketing strategy, international marketing, accountancy for business management, financial management)

- construction subjects (project planning and control, project management, legal aspects of project management)

We must add that the group of general and economic subjects are also taught by teachers whose basic training is in civil engineering, which ensures a multidisciplinary and interdisciplinary approach.

Cooperation among professionals of different profiles from Croatia and European countries provides course members with the most recent professional and scientific knowledge in the field of business management. The study lasts for two years (three terms of lectures and one term for writing the final paper), a total of about 475 hours of teaching, practical work and seminars.

The success of this graduate programme will serve as a basis for forming and opening the Centre of Excellence in Construction Management, with the purpose of developing and advancing the construction potentials necessary for economic and political development and the stability of the country.

4. Conclusion

Croatian builders have proved their construction knowledge, skill and abilities not only in former Yugoslavia but in many countries worldwide, working in different economic and political environments. Now, when our country is becoming part of the European market, the need for the additional schooling of engineers has become obvious, especially in business management in construction, which includes project management.

We consider it useful to bring to mind [6] some “universal truths” about managers, which are also true of managers in construction:

- Managers are only people and have all the human weaknesses: they may look at a problem without seeing it, listen to collaborators without hearing them; they may think about a problem and not do anything, or do things without thinking about the possible consequences first.

- Managers are created not born.

- The “art of management” must be learned, and what is the most important, it can be learned.

For someone to be a good manager or project manager it is not enough to be “talented” for the job or to want to do it. These are no more than good motivation for a person to embark on the tedious course of acquiring the variety of knowledge and skills without which he or she cannot expect to do demanding and responsible managerial work successfully.

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Appendix 1: Results of the year 2003. survey

N=55

Necessary knowledge	Very important	Important	Helpful	Irrelevant
1. knowledge in specific professional fields	11	30	13	1
2. knowledge in economics	13	37	5	0
3.knowledge in management science	41	11	3	0
4. knowledge in project management	31	19	5	0
5. knowledge in information technology	6	31	18	0
6. knowledge of foreign languages	24	23	8	0
7. legal knowledge	3	20	30	2
8. knowledge in social science	5	18	29	3

N=55

Necessary skills	Very important	Important	Helpful	Irrelevant
1. responsibility	37	18	0	0
2. organisational skills	39	16	0	0
3. skills in coordinating tasks and people	41	14	0	0
4. cooperativeness and readiness for team work	20	34	1	0
5. skills in establishing good interpersonal relations	26	26	3	0
6. ability to act in crisis situation	33	21	1	0
7. self-control	24	24	7	0
8. communication skills in writing and speaking	26	26	3	0
9. ability to foresee future events	18	33	4	0
10. decision making skills	45	10	0	0
11. creativity	23	28	4	0

Section IV

Lessons from the Field - Case Studies

Power, Knowledge and Practice: Embedding New Management Initiatives in Construction Firms

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Abstract

Understanding the implementation of innovative management initiatives in construction firms requires an appreciation of the situated nature of organizational learning and the effects of organizing by project on the diffusion of new management knowledge and its embedding in practice. Drawing upon two case studies of the introduction of new management practices in construction firms, this paper highlights two key influences on the nature and extent of change. First, the extent to which new management practices interfere or dovetail with existing project management practice; second, the extent to which they represent a shift in power/knowledge within the organization.

Keywords: Communities of practice, power, knowledge, innovation, learning

1. Introduction

Given the extent of change expected in management practice in the construction sector in recent years, it is surprising that more attention has not been directed towards examining factors influencing change within the construction firm. This is particularly so, given the problems identified by those commentating on prospects for innovation within the sector [1, 2], coupled with results from research that suggest that implementing new management knowledge in construction firms is by no means a straightforward matter [3]. Arguably, the emphasis, until now, has been much more upon examining the *content* of change, as opposed to fully appreciating the effects of *context* and *process* [4].

Recent research, however, has started to question many of the assumptions that underpin broader claims made about change within the sector [5, 6]. As part of this questioning, it helps to understand better the ways in which new management initiatives are diffused, taken up and embedded in management practice. Recent theory and research in the field of knowledge and learning has emphasized the situated nature of organizational learning and the difficulties in transferring knowledge from one context to another [7, 8]. To assume that new management initiatives can be properly understood without an appreciation of the effects of context and implementation process is to ignore the impact of complex organizational circumstances on the translation of new management ideas into practice [9].

The main theme addressed in this paper is that understanding organizational change and learning in the construction firm requires recognition of the constant, complex and dynamic interplay between new and existing management practices within the firm [10, 11]. Project-based working practices have their own logic of action and constitutive knowledge base that define the conditions in which new knowledge and learning is being embedded. These conditions are, in turn, the product of ongoing interactions between discourse and action that are continually being reproduced and adjusted on the basis of experience [12].

This paper aims to contribute to understanding the processes involved in the implementation of new management initiatives by reporting findings from research conducted in the UK (supported by EPSRC grant reference GR/M73286). A comparative analysis is conducted of two case studies to provide an insight into processes of change and to examine the ways in which project-based working shaped new initiatives as they were diffused throughout the firm. The analysis of the cases reveals two major dimensions that influenced the extent to which new management practices were accepted and embedded across projects: whether they interfered with existing project management practice; and whether they corresponded to a shift in power/knowledge within the organization [13].

2. Organizational Change in Construction Firms

Recent work in the field of organizational knowledge and learning has increasingly adopted a practice-based or situated perspective, in which learning and knowledge are embedded in everyday practice [7, 8]. In contrast to a more cognitive-based approach to learning, which emphasizes individualized learning and the abstraction of knowledge from context [14], the situated learning perspective emphasizes social processes and the importance of the context of practice within which learning and knowledge diffusion occur. Consequently, the diffusion of new management initiatives cannot easily be understood without reference to the social context in which it occurs, as well as to existing practices that the new knowledge and learning relate to [8]. However, despite the attention paid to understanding the diffusion of knowledge and learning across complex organizational forms [10, 15], there remain a number of major omissions in the way in which knowledge diffusion and learning processes within communities or networks of practice have been explored.

The first major omission concerns the effects of variation in organizational context and, in particular, the effects of project organization [16]. The form of organization is likely to have a significant impact upon knowledge diffusion and learning processes. Project-based organizations, in particular, represent an especially challenging setting for organizational change, knowledge diffusion and learning, since they often require the development of dedicated modes of organization and management practices that may not align neatly with more routine organizational processes [17]. The dispersed nature of project-based working in construction creates a highly decentralized and de-coupled system of working [18]. This has implications not only for the development of a strong and coherent alternative body of knowledge that is manifested in commonly adopted project management practice. It also has implications for the creation of distinct domains of control and influence within the organization, based on differentiation by project [16].

The second major omission relates to the relative lack of consideration of the effects of power on organizational learning processes [19]. The introduction of new management practices not only confronts existing management practices and routines in a very direct and practical way [12] but, in doing so, potentially challenges and sets out to replace ways of working and relating within the organization that constitute particular configurations of power/knowledge [13]. In other words, the shift towards a new mode of organizing or working practice is likely to involve an attempt to institute a new 'normalized' mode of working that inevitably advantages some individuals/groups while disadvantaging others – in terms of their expertise and therefore control over technical and/or managerial processes [19]. Indeed, achieving such a power/knowledge shift is often a very explicit aim of introducing new management initiatives [20].

Consequently, attempting to understand change in the construction management context brings to the fore the difficulties associated with attempting to embed new knowledge and learning in a context where there already exists a strong project orientation, where existing organizational mechanisms may be temporary and far from all-embracing; and where existing knowledge may be deeply embedded in dispersed managerial practices. Taken together, these points suggest that there is much to be gained from exploring organizational change in the construction context from a perspective that emphasizes the socially situated and contested nature of knowledge and how the particular organizational context affects processes of embedding (or attempting to embed) new management knowledge.

3. Research Methods

In order to undertake this task, research was undertaken in a number of case study construction firms in the UK. The research consisted of several case studies, two of which are reported here. Further information about the other cases can be found elsewhere [16, 21]. In each case study company, one managerial initiative aimed at having a significant impact across the organization was selected. The initiatives chosen varied considerably and included the new risk management system and new estimating process studied here.

The research was interview-based, with data from the interviews being supplemented with documentation, including internal company reports and presentations. Managers selected for interview were those directly involved with and affected by the initiative and included senior managers, project managers working on sites and professionals (e.g. engineers, estimators). Interviews lasted about an hour and all were tape-recorded and transcribed. Open ended questions were asked about the person's background, their understanding of the initiative, the wider commercial and corporate context, the implementation process used, changes to working practices, and overall effects and outcomes.

Data were collected over two years by having key people interviewed more than once in order to track developments and examine more closely emerging themes. This real time investigation, combined with retrospective accounts, allowed some longitudinal examination of the process of introducing change to working practices. The orientation to data collection and analysis was exploratory, intended to generate insights into how new knowledge associated with the initiatives was being interpreted and acted upon by those that the initiatives were designed to effect.

4. Case Study 1: Betta Process

Betta Process is a medium sized firm, specializing in the building of food, chemical, petrochemical, materials handling and nuclear processing plants. It employs around 250 permanent staff, 70% of which are professional engineers. In 1999, the company underwent internal restructuring, which led to a rebalancing of the power structure in favour of the project management axis of the company's matrix organization. The responsibilities of engineers became limited to maintaining/improving technical skills, while resources were now managed centrally. Project managers became responsible for employees' performance evaluation, which was directly linked to remuneration. At the same time, some 'cultural change' was already apparent as people started to identify themselves more with projects than with departments.

At the end of 2001, a new Risk Management System (RMS) was launched. Market pressures and a recent shift to fixed price projects had resulted in dissatisfaction with how risk was being managed. The new system aimed at bringing more precision and accountability, through introducing highly structured and quantified analysis provided by a software-based tool. The RMS was used at the bidding stage of the projects as well as for project management. The scope of the initiative was restricted at first to 'big' projects. One reason for this was that it was too time-consuming to apply the RMS to smaller projects, as it became a risk liability itself.

The new Risk Management System at Betta Process was designed to provide a more systematic risk assessment. It affected existing project management practice directly, since project managers now had to perform new, additional procedures. As one of the senior managers explained,

> Probably, for the people that are actually using [the system] it does not make a whole load of difference. They have a job to do that they did not have to do before. They have to sit down on a monthly basis and punch numbers into the system. What it has done is made a lot of difference at management level as to the degree of confidence they have in the assessment of the financial health of a particular project.

In addition, it also directly affected the degree of financial control exercised by project managers. As a senior manager explained,

> One of the less attractive features of the thing, from the project managers' point of view, is that it gives the project manager far less scope on his project for being able to control his budget because if he identifies a risk as being passed the funds will disappear.

However, in order to use the new system, project managers still had to rely heavily on their expert knowledge. Although the tool itself was well documented and formalized, its use remained extremely subjective and depended on the experience of the estimator or project manager. As one project manager put it,

> It tells you how to use the system just like your car manual will tell you how to operate the car. It does not tell you how to drive the car. And what to do when that pedestrian steps out in front of you.

At a later stage of implementation, the experience-based component of risk assessment was recognized by senior management as being more important than the calculations performed by the system. The tool was "de-sophisticated" to reflect this. Risk categories were simplified and project managers were allowed greater flexibility in interpretation and use.

The introduction of the initiative did not imply any great shift in power or influence in the organization. Project managers' knowledge continued to be highly valued as a crucial component in risk assessment. Even though the new system brought more transparency to project managers' practices, their prevailing concern was how to learn to use the new system. Training had only consisted of one session, in which a 'dummy' project was used to demonstrate the system's functionality. Besides that, people were supposed to be "able to understand what was needed" and expected to learn how to use the tool by applying it. As one project manager recalled,

> The problem with this is you have to apply it. You have got to do it and you have to do it more than once. Each time you do it you get better. So you have to understand the limitations of the system to make sure that you get the right inputs.

The new Risk Management System was applied to two major 'pilot' projects, which allowed project managers to change the way they managed projects. By the time of the completion of this research, the new RMS was considered successful and had started to be applied more widely across the organization.

5. Case Study 2: Delta Oil & Gas

Delta Oil & Gas is an international business with a £65m turnover and 300 employees, including a high proportion of highly qualified engineers, designers, and project managers. They work mainly for large 'blue chip' clients such as Shell and BP and operate in an environment in which oil and gas price movements are cyclical and volatile. A downturn in 1998 affected the company so much that it was forced to engage in significant restructuring and downsizing and was only now fully recovering.

In this context, it was felt that a new approach to estimating was needed. The overheads associated with bidding for jobs were mostly attributed to the amount of man-hours spent by engineers on estimating. The new approach would rely instead on computer-based tools rather than engineers' direct input. The objective was not only to simplify the estimating process, but also to change the role of engineers and how they were used in the company – transferring the ownership and responsibility for estimating to estimators. This approach would also mean greater involvement of project managers in estimating and more interaction between them and estimators during project implementation.

The backdrop to the change was what was seen as the strong departmental culture within the organization, particularly in engineering, which was seen by other groups as responsible for overspending and working in isolation. According to one project manager:

> Engineers are engineers. They want to design the best thing in the world, don't they? That is all they really want to do. It does not matter how much it costs, or how long it takes. […] A lot of them just do their little bit of work in isolation, that is all they ever do. They don't look at the big picture, certainly time and programme.

With the introduction of a new estimating process, project managers welcomed their greater involvement with estimating and the greater shared responsibility between them and estimators. This did not affect their project management function very much. However, it did allow them to have greater influence on the outcomes of the estimating process. It also proved to be useful in dealing with clients, as project managers would have greater knowledge of the financial side of the projects.

Not surprisingly, the changes were perceived very differently by the engineers, who found that the new way of working and their reduced involvement in estimating went against their existing norms and practices. As one engineer commented,

> I have never worked that way. … I am sitting there and I have not been given a copy of the invitation to tender … I think, 'What on earth am I meant to be doing here?' … I think, well, why I am only getting selected documents? I have got to know what's going on. I need a complete set or need open access to a full set of documents.

The new way of working also involved less recognition of the engineering function in the organization. As an engineering manager commented,

> During the compilation of any estimate, [we're] being constantly asked questions by [the estimator or project manager]. How do you do this? What would you do here? How much would you allow for this? How would you arrive at the figure to do that? But when an estimate is tabled it is 'This is my work'. Hence, my resentment.

Although responsibility and control were passed more to estimators and project managers, engineers continued to be the gatekeepers of the knowledge and information needed. Most of the formal communication protocols, such as sharing of detailed information from meeting minutes during bidding, were eliminated by the new estimating procedures. Estimators and project managers had to rely on informal means of communication by "scribbling notes themselves" and engaging in "sweet talk" with engineers to be able to complete the estimates.

Project managers found learning estimating skills even harder. Not only were engineers unwilling to surrender their expertise and influence in the company, but project managers relied critically upon the knowledge of estimators. As one project manager remarked,

> The estimators have intimate knowledge … They understand the functions and the basis [and] you could only interrogate that basis to the extent of your knowledge. Once it had gone beyond that, the estimator could tell you anything he liked because you didn't know any different.

Consequently, even though the new approach to estimating did not significantly influence project managers' everyday practices, it did nevertheless continue to leave them dependent on significant others for knowledge and information relevant to how they did their work and, despite their efforts to develop expertise and skills in this area, did cause them difficulties in attempting to develop their own knowledge base.

6. Case Analysis and Emergent Themes

Of course, a variety of factors – amongst others, the approach to introducing change, the support of senior management and the availability of resources – were important in influencing overall how these two initiatives were implemented and how successful they were. However, as the context and implementation of the particular initiatives being explored across the cases became better understood, it became clear that the variety and distribution of existing management practices, and the degree to which change initiatives were seen to interfere or dovetail with these practices, had an important bearing upon the ways in which new organizational knowledge was accepted and embedded within the firm.

Taking such a situated perspective, two key dimensions emerged strongly from the data. First, the more that the change initiative interfered directly with project management practice (and was intended to do so), the more important became established ways of working and frames of reference used by project managers, as these provided more immediate templates, sources of meaning and legitimacy than the wider company initiative. Second, the degree to which the introduction of the initiatives disrupted existing power/knowledge relations within the organization influenced whether managers reconstituted their knowledge by changing their practices or, alternatively, subverted or resisted the new initiatives.

The positioning of the cases with respect to these two dimensions is depicted in Figure 1 below. At Betta Process, the introduction of the new RMS can be interpreted as having a relatively low degree of disruption to the knowledge/power balance in the organization concerned, but a very high level of impact upon existing project management practice. Despite being a more structured system, it continued to rely for its implementation on the expertise of project managers. This, combined with the willingness of senior managers to defer to their project managers' expertise, allowed them significant latitude in deciding how to use and apply the tool. Before the introduction of the RMS there were no well-defined routines established across projects about how to assess risk. Although the new system implied significant changes to how projects were being managed, the willingness and ability of project managers to learn new skills facilitated the enactment of this newly introduced system and contributed towards its embedding across projects.

		Disruption of knowledge/power balance	
		Low	High
Interference with PM practices	Low		Delta Oil & Gas New Estimating Process
	High	Betta Process Risk Management System	

Figure 1: The Case Studies

At Delta Oil & Gas, the new estimating approach very clearly signified a power/knowledge shift, involving an enhancement of the project management function at the expense in particular of the engineers. In introducing a different sort of 'normalized' working practice across the firm which subordinated engineers' interests and expertise to those of project managers and estimators, the new process very much represented a shift in power/knowledge within the firm and a challenge to existing professional identities [13]. Moreover, by getting involved with and attempting to learn estimating skills, project managers were able to refine their role and identity further as those with more autonomy and expertise to control their projects and deal with customers. Estimating activity was not central to everyday project management practice. However, participation in this activity could make project managers more knowledgeable about the financial side of the projects and, consequently, provide them with greater control over their job.

7. Concluding Discussion

This paper has attempted to examine some of the key problems in implementing new management practices in project organizations, when the practices concerned are expected to affect project management work. Using an approach informed by a situated learning perspective [7], this paper draws upon two case studies of the introduction of new management initiatives in UK construction firms. The analysis of the cases highlights the importance of understanding existing management practices and how they align with new ones being introduced; as well as the degree to which the adoption of new practices disrupts power relations within organizations.

The findings demonstrate that the distributed work practices common to construction firms who base their activity around projects have an important bearing on the shaping and embedding of new management practice, since they directly influence the ways in which broader organizational initiatives are interpreted, legitimated, modified and incorporated within practice. Locally established project management routines, in particular, provide a useful means of re-interpreting and making sense of new practices so that they conform to existing and preferred local norms and values. Furthermore, distributed power domains and group identities based on the control by groups over a particular expert knowledge base, influence change processes quite markedly within such organizations.

These findings not only reinforces the notion that conflict is essential in understanding the learning dynamics associated with the embedding of new knowledge across projects, but also demonstrates how power dynamics can work themselves out, through the creation of new normalized modes of working that differentially influence the expertise, influence and identity of diverse expert groups. More generally, the findings lend support to the idea that the introduction of new management initiatives is often hampered by a failure to understand existing underlying routines [12]. And that project basing poses particular constraints on attempts to diffuse new knowledge and learning because of the dispersed systems of practice that arise in such circumstances [10]. To the extent that the exercise of power and control is integral to understanding learning processes within organizations and wider communities of practice [19], then project-based organization such as found in construction poses particular challenges for the diffusion and implementation of new management ideas.

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Project Based Innovation and Partnering in the Swedish Construction Sector

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Abstract

Although diffusion of innovation in general is slow in construction, single projects may show significant levels of innovation. Partnering is often related to innovation and has been an important aspect of construction sector reform initiatives. In Sweden, there is a strong but declining tradition of standardization by regulation in construction, and partnering has not been promoted by the government. This paper analyses the relation between project-based innovation and partnering in a Swedish context. It is concluded that although the driver for partnering is more often cost-reduction than innovation, partnering can bring about innovations. These often concern processes and systems, which can be important enablers in a long term perspective. More partnering projects are needed to bring attention to those systems, and thus increase the potential for innovation.

Keywords: Innovation, partnering, Sweden

1. Introduction

Often when innovation in construction is discussed, the low pace of innovation and limited learning between projects is emphasized and analysed [1]. Clearly, many projects are carried out according to a standardized process, using mainly standardized components and measures. In recent years however, following the development of the CoPS paradigm specifically developed to address the conditions for innovation in the context of large, unique, complex projects, the role of project based innovation in construction has gained more attention [2]. Several authors have observed that although diffusion of innovation in general is slow, single projects may show significant levels of innovation [3,4,5]. Many of these examples are found in large prestige projects, but there are projects that are more innovative than others also in the domain of more everyday residential and office buildings. Indeed, the degree of innovation seems to vary considerably also within a project category.

Partnering, or more collaborative relationships between project participants, is often related to innovation. In the UK, partnering has been an important aspect of construction sector reform initiatives proposed by the Latham review as well as those following the Egan report. Winch [6] saw partnering as a key to innovation because of the opportunities for introducing gain-sharing mechanisms to encourage project actors to engage in client-focused innovation.

This paper investigates project-based innovation in Swedish partnering projects. A main case study of a project with explicit aims to increase innovation is used to discuss the measures employed by the actors to encourage innovation and the drivers involved. To discuss the role of partnering in relation to innovation, the main study is supplemented by three additional case studies of partnering projects. Important questions are: To what extent is partnering motivated by concerns for innovation? What processes and mechanisms are put in place to support partnering and how do these relate to innovation? What kinds of innovations are likely to occur?

First, however, a background to the Swedish situation is outlined, highlighting the need for an historic perspective and understanding of the institutional context.

2. A Swedish Background

In an industry that is based on temporary multi-organizations but were the products carry a great deal of similarities, the potential for efficiency to a great extent lies in standardizing both the physical and organizational components, and the rules of interaction between the organizations involved [7]. Sweden has a particularly strong tradition when it comes to such industry level standardization. In the period between World War II and the 1980’s, governmental regulation in the building sector continuously grew. Building codes increased in detail, which, in combination with subsidies tied to different aspects of dwellings brought a standardization especially of residential buildings. The concept “subsidies architecture” was coined, as designs were developed to maximize subsidies rather than optimize for user needs, and superior quality was rare.

In the late 1980’s and early 1990’s, government increasingly loosened its control over the construction sector. A new legislation was introduced, explicitly stating that the client is responsible for the quality of the building, and not the local authorities issuing building permits. In steps, the detailed codes, where possible, were replaced by performance requirements. As a part of a major effort to cut back public expenses the subsidies were significantly reduced in the early 1990’s, leading to a sharp cut in residential construction. Demand continued to be low until the next boom in the late 1990’s. Then, construction volumes grew due to commercial buildings and tenant-owner housing, but the previously so important sector of multifamily dwellings for rent remained very limited (but has increased in volume in 2004-2005).

In the previous system, knowledge of the codes and the subsidies became more important to the industry than professional knowledge concerning space planning, architecture or technical systems. The new system seems to call for a higher level of professional competence, but change has been hampered by a lengthy recession followed by a short but intense boom in 1998-2000 when, especially in the Stockholm area, cost considerations were of less importance. Thus, circumstances more favorable to sensible innovative practices have only existed for a couple of years, and it is hard to know if any changes have taken place in practice.

Contrary to many other countries, for example the UK and Denmark, the Swedish government has not pointed out partnering as the preferred procurement route for government sector clients or in any other way promoted partnering. Sweden, however, has a tradition of more collaborative construction relations and low visible costs for conflict resolution. Also, the Swedish construction market is dominated by three large contractors. This may explain why the Swedish discussion and government initiatives have focused on the need for increased competition. The interest in partnering has increased but it is only in 2004 that the Road and Rail authorities, as the first government sector clients, have declared a commitment to developing and using partnering principles, and there are no authoritative guidelines on the subject. Measures and principles tend to be developed by the parties themselves, sometimes inspired by foreign models, but often rather informal, not requiring much extra resources.

3. Methodology

The main case study concerned the new Stockholm office of White arkitekter, one of Sweden's major architectural firms, designed and commissioned by the company itself. This project had an explicit focus on innovation, and was carried out in a partnering environment. The finished building has won several prestigious Swedish awards within architecture, construction and concrete design. The case study started towards the end of the construction phase and was finished at about the same time as the project itself. A total of 14 people were interviewed, representing the project management, tenant, client and architect functions within White; technical consultants; the main contractor's project manager, site manager and purchasing agent; building services contractors and a cladding manufacturer.

The other case studies were studied in a previous research project focusing partnering and collaboration, and were chosen on the basis of their partnering content. Thus, these inform more generally on the role of innovation in partnering projects. These case studies were carried out in 2001. In each project between four and eight interviews were conducted, depending on project size and complexity. Both client and contractor representatives were interviewed in all projects, and the architect was interviewed in two of them.

First, the main case study will be described and then the other four will be briefly introduced. Discussion and conclusions follow.

4. The New Office Building of White Arkitekter

4.1 Background and Aims

In 2002, one of Sweden's major architectural companies was located in an ancient building in the Old Town, in facilities which were pleasant but too small. Also, the technical systems did not fulfil the requirements of a modern computer-based design office. White had been investigating different location alternatives for some time, and had found that a new building would not be more expensive than refurbishing the existing premises or renting larger and more modern facilities in the centre of Stockholm. Also, a new building had other advantages: it gave the company an opportunity to create a best practice case were they could demonstrate the capacity and competence of their firm. As the company has a project management unit, best practice aspects would concern organization and management as well as architecture.

Compared to many other countries, such as the UK, Denmark and Norway, Swedish architects have less influence and responsibility. Since the 1960's, it has been common that the client, in traditional contracts, appoint the architect and other members of the design team to carry out the design but that all contacts with contractors and the construction site are then handled by the client's project management team. Thus, architects and engineers often have little knowledge of constructability aspects. Also, there is a general rule that the contractor is entitled to replace specified components, qualities and trademarks with other "equivalent" products. As aesthetic aspects are difficult to specify in objectively verifiable terms architects in particular are frustrated with this rule, claiming that contractors take advantage of this opportunity to replace carefully selected designs and products with cheaper ones of lower aesthetic and functional quality. People at White were of the opinion that the construction process would benefit from a closer contact between the design team and the contractors, so that price-quality trade-offs could be decided in a discussion with all relevant competences present.

White was also critical to the low level of innovation in the Swedish construction industry, and thought that clients were much too risk-averse in their choice of architectural design as well as technical systems. They claimed that more cost-efficient and fit for purpose solutions could often be found if other alternatives than the standard ones where considered. In particular, design of building services systems could be significantly improved and better integrated with the load bearing frame. However, as HVAC engineering firms are mostly asked to provide standard off-the-shelf solutions they have little incentives to develop innovative or even best practice design competence. Also, the building frame is decided at a much earlier stage in the process than the HVAC-systems which makes integration problematic.

Thus, White had many objectives in assuming a client role when acquiring new premises. In sum, these were to:

- get facilities adapted to their business needs
- show that the firm had a high competence concerning architectural design as well as project management
- show that a better architectural quality does not necessarily lead to higher costs, but that the architect has to have a stronger influence in the project
- show that design consultants bring value in the construction phase
- show that encouraging innovative thinking in the design of technical systems can improve building performance at a lower cost

- propose a quality- and innovation-orientated model for project organization and management

The only problem was that the partner-owned architectural company neither wished to take the long-term risk of owning a building nor deal with everyday facilities management issues. Thus, they had to find a property owner who was interested in buying and owning the completed building, renting 2/3 of the building area to White for period of 10 years.

4.2 Strategy and Model

White had the ambition that the building should be an example of integrated design, where the building services systems are integrated with the structural frame and the physical systems are exposed and form a part of the design. To achieve this, a design contest for HVAC engineers was carried out. This procedure is common for encouraging creativity in architectural design, but is generally not used in engineering. However, the three companies asked were positive, and they developed three different and unconventional (although not totally new) solutions in a rather short time. White was satisfied with the result, and chose a design where pipes where placed inside the concrete slab and sea water was used both for heating and cooling by means of a heat exchanger (the building would be located just by the waterside). Thus, the concrete frame was exposed which conformed to the aesthetic aims. As most electric conduits and piping for ventilation would also be visible, the quality of workmanship would have a direct influence on the architectural expression.

Normally when clients want to have control over both building quality and costs, they prefer a highly specified traditional contract with a fixed price agreement. White initially considered this alternative, but found that it would not grant them enough control over all building details. Instead, a partnering approach was chosen, and a contractor was engaged at an early stage. The contractor participated in the design process and a target cost was set, but there was no gain-sharing mechanism. The client and the contractor agreed that a target cost-incentive fee arrangement would seriously hamper collaboration and be a source of distrust. Thus, the client had to trust the contractor to engage in economizing without economic incentives, but could be confident that the contractor’s suggestions were motivated by a concern for the project. The subcontractors, by contrast, were procured by traditional means on a fixed price basis, and in most cases the company with the lowest tender was appointed. However, only trusted subcontractors were invited to tender.

The partnering model was informal in the sense that no teambuilding exercises or workshops were held. There were no systems for continuous evaluation other than the ordinary ones. Still, there was more project communication and shorter communication channels. A project group was formed including the main decision-makers, which met regularly during the whole project and discussed all decisions of great aesthetic, functional or economic importance. The design phase was carried out in a traditional manner, with the only difference that the contractor participated. New to the consultants was that specific meetings were held for selected systems, were different manufacturers were invited to present their products to the client and consultants. Also, the partnering arrangement allowed the client and the design team to participate in subcontractor procurement, so that they could discuss problems and the requirements concerning quality of workmanship before the contract was signed. During the construction phase, there was close contact between the consultants and the contractors.

4.3 Process and Results

During the first part of the project, most things went better than anyone had dared to hope. The important and costly pre-cast frame and cladding system were procured at a lower cost than previewed. Everyone was excited, and White decided to use money now available to upgrade some designs that had been subject to savings in early stages. However, later in the process, when it came to purchasing of components such as interior wall cladding, staircases and other visible products, prices turned out to be much higher than estimated. The architect had designed non-standard solutions, but as the basic material itself was low-cost and designs simple he thought that these were cheap. But as it turned out, the manufacturers were not very interested in supplying customized products and came up with very high prices. And by then it was too late to find other suppliers or cut back other expenses. So in the end, the cost exceeded budget by 4%, but included quality upgrading representing 7%.

Concerning innovation, the most innovative solutions came up in the design contest. The integrated design concept, however, had further effects. Normally in office buildings there is a sub-ceiling with sound absorbers, but this would compromise the whole design concept. Instead, the architect contacted a Danish acoustics consultant who made computer simulations of how the t-shaped elements of the concrete ceiling would affect the diffusion of the sound waves. It was found that the requirements would most likely be fulfilled without any absorbents at all. Thus, White could keep to their design goals by challenging conventional knowledge.

The collaboration with the building contractor was not strongly innovation focused and brought mainly constructability improvements, although in one case this lead to a significant design change. White was very satisfied with the contractor's contribution to the project, and there were no feelings that the commitment to keeping costs down was lacking. In fact, also the subcontractors were very engaged despite the fixed price/low bid procurement. The reason, they said, was the direct contact with the client in the procurement phase, and also that their tender prices were realistic. The collaboration between the consultants and the contractors as well as the quality of workmanship was excellent. The only problem was that there was too much communication. The craftsmen tended to check very small details with the architect, who willingly answered. The project manager found it a difficult balancing act to encourage contractors to come up with ideas, but still be able to turn down some suggestions without a loss in motivation. The architect, in hindsight, thought that it would have been possible to be more restrictive if there had been a greater consciousness of the problem.

The project goals were more than fulfilled, as the finished building has won the single most prestigious Swedish award within architecture, as well as the contractors' award and an award for the concrete design.

5. Three Partnering Projects

5.1 MedicHus

MedicHus is a municipal agency responsible for old people's homes in Göteborg, Sweden. In the end of the 1990's, the agency started a project to refurbish a series of 16 homes using traditional procurement routes. The interest from contractors in MedicHus' projects was low, manifested by tenders more than 50% over the client's estimate. After a couple of projects, MedicHus decided that they had to find a different approach and started by asking local contractors for advice. The result was a model where the main contractor would be selected mainly on the basis of competence, and MedicHus specified a general standard for the old people's homes and made a detailed estimation of the project costs. In their tenders, the contractors were required to comment the cost estimate, and a target cost was agreed. Gains were then to be shared between the client and the contractor. No explicit teambuilding efforts were undertaken, but the contractor was given sufficient time for planning and procurement of subcontractors before construction started and great care was taken in selecting the right people on both sides. Collaborative relations then came about spontaneously during project planning, where the client staff and contractor staff worked closely together. Each project was procured individually. The first project was completed on half the time needed for a traditional project, and at about 15% below the target cost.

5.2 KappAhl

KappAhl, a clothing company with their own retail stores, needed a new head office. The building would house the design department, why architectural aspects were important. A distinguished architectural firm and technical consultants prepared drawings for a traditional contract. However, costs were found to be too high and a project management consultant was engaged to revise the project. The brief was reworked and floor space was significantly reduced. For time reasons it was decided to use a rather detailed design-build contract, but the architect would continue to work for the client. A contractor was appointed, partly based on their price and partly because they came up with several ideas for improvements. The project management consultant suggested a target cost-incentive fee mechanism for a number of well defined areas (e g a special flooring and façade glazing). Open books were used, and a group including the client, the project manager, the architect and the contractor met regularly to discuss the incentive areas.

During the project, several complications came up. Following a company acquisition more office space was needed, and the building had to be redesigned when the construction had already started. Also, the first incentive discussions were difficult because the architect did not accept the contractor’s proposed alternative for façade glazing system, which in addition turned out to be much more expensive than predicted. However, the collaborative arrangement allowed the project manager and the contractor to meet jointly with the glazing manufacturer and together negotiate a lower price. In the end, the problems strengthened mutual trust. The other incentive discussions were constructive and the project was considered very successful. The deadline was met, the quality was high, the costs were under (the already low) budget and all parties were very happy with the teamwork.

5.3 The Central Hospital of Karlstad

In the late 1990’s many buildings at the Central Hospital of Karlstad were in bad need of refurbishment. The facilities management function expected about 30 projects, and it was decided to develop a partnering model to handle this large construction more efficiently. The agreement was based on plans that 20,000 sqm were to be refurbished during a period of almost three years. A design-build contractor was procured, mainly based on their competence and attitude. Initially, several joint workshops were held for teambuilding and for establishing project goals and routines. The economic agreement consisted of a fixed price part that should cover central administration, profit, insurances, etc. for the entire program, and a cost reimbursable part covering the direct costs for wages, material etc. for each specific project. The design-build contractor had an increased liability: 5 years product warranty and 10 years performance liability for indoor climate. It was stated that the contractor should define technical solutions together with the consultants and the hospital staff. In each project a pre-study was carried out and priced, and a formal contract was written.

The project faced heavy time constraints and important changes in project contents right from the beginning, and early in the process the client project manager was replaced. The first project exceeded budget and the client-contractor relationship deteriorated somewhat and at least temporarily resembled that of a traditional project. No follow-up workshops were held. Despite these conflicts and tensions, all participants were positive to the new way of working. The design team and the contractors worked more closely together than in conventional design-build projects, and new visualization tools for showing contractors and users how technical equipment would be placed in a room were developed jointly. Construction work was of a higher quality and contractor-user relations were improved. However, it was difficult for the contractors to stand up against the requirements of chief physicians and they found their roles in project definition unclear. The new procurement concept and 10-year climate guarantee required many systems to be developed, especially for sub-contractors and facilities management.

6. Case Summary and Discussion

6.1 Innovation

Of the projects, only the White case was explicitly orientated towards innovation. The most important measures chosen to bring about new solutions in this case were the design contest for building service consultants, choosing top consultants and allocating more resources to the design phase. These measures proved effective, and the project included much more unconventional solutions than usual. Still, all these measures could have been used in a traditional contracting environment, while the closer collaboration with the contractor mainly was about ensuring that the architect could influence all project decisions, cost control, and improved constructability.

However, it became clear that also this kind of process and relationship innovations, in combination with a closer contact between consultants and contractors, required new processes. First, it was obvious that the traditional purchasing process is not suitable in a project with a significant share of non-standard solutions. To manage risk of low supplier competition requires, first, that also seemingly simple non-standard designs are identified and investigated at an early stage and, second, a broader knowledge among both consultants and contractors of possible suppliers (also foreign) to shorten search times.

The other cases showed similar tendencies that contractor collaboration focused mainly on cost control, cost savings and constructability. Regarding innovation aspects, many important areas of innovation came up not as an answer to client requirements or cost consideration but to organizational and process needs. The changed purchasing environment was one example, and in the Karlstad case the FM-unit needed new data bases and improved control systems to be able to distinguish system performance from management performance in relation to the increased performance liability. The visualization system was also a need stemming from a closer and more long-term relation between consultants, contractors and users. In the White project the increased consultant-contractor interaction called for new management skills. Thus, the driver for partnering are often be cost-based, but partnering itself then calls for process and system innovations.

6.2 Collaboration Aspects

Despite the general Swedish collaborative mentality and the tradition of informal co-operation, the participants found that the initiatives to increase collaboration in the case study projects made a difference. Inter-organizational teamwork was perceived as significantly better than in “ordinary” projects. In the White, MedicHus and KappAhl projects, the client side was sensitive to the needs of the other parties and made efforts to facilitate their work. There was an emphasis on listening to and respecting other parties’ opinions, a culture that was perceived as rare by those involved. Especially contractors felt more appreciated and found their work more meaningful. All projects reported better quality of workmanship. The overall attitude towards partnering was strongly positive and all of those interviewed wanted to develop partnering further. In two cases, there were incentives (gainsharing mechanisms) and in two there were no incentives. However, the White case demonstrates a strong contractor commitment without any incentives, and the interviews indicate that emotional rewards and intrinsic motivation are very important.

6.3 Formalization

In all cases except Karlstad, the level of formalization was low when it came to collaborative initiatives. Great care was taken in choosing the right people, but no teambuilding initiatives took place and there were no routines for regular joint project evaluations and conflict resolution. In the Karlstad project, workshops were held to promote teambuilding and to establish routines for project work and economic evaluation. However, when problems appeared and a new client project manager took over, there were no more structured initiatives for repairing relations or for joint reflection. It seems likely that these problems, as well as the problems of finding the proper level of consultant-contractor communication in the White project, could have been at least partly sorted out if there had been collaborative and pre-planned evaluations.

7. Conclusions

It was only the White case that there was an explicit aim to find new solutions, and the driver was partly a desire to participate in an ideal project, and partly to create a demonstration project to market the company. This intentional innovation was handled by traditional methods: design contests and more resources given to design. In all projects, reasons for partnering were primarily related to reduced conflict, cost and quality control and smooth project execution. The new relations, however, called for new processes, systems and management skills. These needs often came as a surprise, because beforehand the client's main worry was whether they could trust the contractor, not how a successful trust relationship should best be managed.

Some of the needs were handled within the projects, but some were left open, maybe to be picked up in the next project of the same kind. Thus, to increase the potential for project-based innovation in collaborative projects, there has to be more of this kind of projects. Then the parties will develop knowledge, skills and systems to fit a collaborative environment. And when there is less focus on trust, innovation can be expected to come up as an important management area. Thus, Swedish government might be advised to more actively promote partnering and develop guidelines that will help the parties to build up systems supporting project-based innovation.

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Team ‘Working’ & Project Performance in the UK Construction Industry

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Abstract

This research programme is currently investigating the relationship between construction site teams and project performance. Much has been written about the benefits of team working and over the last decade management thinking has shifted the typical team paradigm away from a traditional operational application towards an increasingly strategic perspective. The employment of team working within the construction industry is extensive and therefore any development on the management of teams and team working applications may have a far-reaching significance for the sector.

The company case-study investigates the relationship between two ever-present variables in most construction projects: teams and performance. The team study identifies three contextual categories that comprise of seven key characteristics prominent in most group / team environments. The individual team variable ratings are calculated using an attitude statement questionnaire that has been issued to all permanent construction site team members. The questionnaire addresses all seven key variables; each variable has five attitude statements with five possible answers. The individual responses are collated, averaged and presented collectively as a team percentage rating by means of a radar chart. Project performance is evaluated using seven key performance indicators. The KPI’s have been selected to create a balanced performance measure of project ‘well-being’, incorporating the four distinct perspectives advocated in Kaplan and Norton’s Balanced Scorecard concept. The project performance data is gathered from three primary sources: the client or client’s representative, the team leader and construction site team members with specific reference to the seven key performance indicators adopted from recognised construction industry KPI’s and similarly presented on a radar chart.

Analyses of the results quantify the perceptible strength of relationship between team working and project performance. Results also identify individual strengths and weaknesses. In particular team characteristics that may contribute to project quality for the client and promote continuous team improvement for the contractor. Further detailed investigation and data collection has the potential for future development of a diagnostic toolkit that may unlock team working capability. If construction teams are to be better managed then the interaction between site team working, performance and the environment requires to be better understood.

Keywords: Teams, Performance, Key Performance Indicators, Construction Management.

1. Introduction

Team theory is a resilient management theme; the notion of team theory has a long history and in the second half of the twentieth century its theoretical and practical contribution to work place management has been the subject of numerous studies. In a time of ever-changing management fads, corporate interest in teams and team related philosophies has remained steadfast. Some commentators argue that the need for team working in the present corporate climate is even more pressing that in previous times, “developments in modern manufacturing methods and service excellence have put greater emphasis on team working”, [1]. Today, global industries ranging from aerospace and car manufacturing to financial services and the public sector have embraced team ideals in the search for improved efficiency and overall company performance. It is interesting to note that there is a discreet difference in today’s team philosophies with that of previous years. The traditional team working research perspective of the founding behavioural scientists was, in essence, benevolent in its concern, “the principle managerial and social science concerns have been with morale, [2]. While contemporary application of team management theories focus primarily on the needs of the business, “considerations of performance have obviously contributed to the growth in importance of team working during the 1990’s”, [3]. This viewpoint is endorsed by Marchington [4], stating that “more recently, there have been few doubts that the attractiveness of the team concept has rather more to do with gaining competitive advantage through advances in productivity and quality – which may be enhanced by teams, than with any altruistic motive”. The current wave of management thinking has shifted the traditional team paradigm. The rationale for the adoption of team working in the twenty first century is to achieve competitive gains and efficient organisations via effective management of human resources. “The objectives, in other words, are strategic rather than operational”, [5].

2. Teams and Project Performance

2.1 Teams

Team is a common, everyday expression yet an exact definition remains elusive. Dictionary descriptions tend to communicate an overtly casual application of the team ideal, out with any specific context and over-simplifying the team dynamic. Management interpretation of team virtues supplement the familiar interpretations by acknowledging group activity and introducing the need for a commonly shared objective. Katzenbach and Smith [6] suggest that the team definition would be better articulated as a “discipline that real teams share”, stating that “a team is a small number of people with complementary skills who are committed to a common purpose, set of performance goals, and approach for which they hold themselves mutually accountable”. Unfortunately, the liberal use of team vocabulary with everyday management rhetoric may in effect dilute the true collective nature of team orientated operations and “carries with it the danger that team working will lose all meaning”, [7]. “As terminological precision is so elusive, it is perhaps more appropriate to focus attention on how aspects of organisational context influence the different forms of team working adopted”, [8]. A failure to recognise corporate limitations may inhibit team performance. Examples of unsuccessful team working have highlighted the role organisations play in the formation and support of collaborative effort. Lack of attention with regard to existing company policy, procedures and customs may hinder the team effort. Jasmine Tata [9], recognised the significance of corporate environments stating that “work teams do not exist in a vacuum, but are part of a larger organisational system with distinct cultural and structural characteristics”. In other words, the introduction of team working philosophies may contradict existing company practice. Companies should endeavour to establish a degree of compatibility between existing working procedure and those associated with a team-based orientation. Organisational context will shape the team dynamic and as such will redefine the generic meaning of the team within an organisational specific setting. Industry customs and beliefs may also influence the exactness of the team definition. It may therefore be argued that a standard team definition is malleable enough to reflect the various contextual attributes that all teams invariably possess. The application of teams within the construction sector is extensive where, “construction is arguably the largest collectivist activity” [10], of all the UK sectors. Over the past decade, construction company awareness of team working practices has reflected the growing corporate management interest in team related theory. Construction project teams require a multi-functional, inter-disciplinary representation, engaging a cross-section of industry professionals responsible for carrying out duties particular to their area of expertise. This type of team arrangement is representative of a cross-functional or matrix team formation. The appeal of high performance cross-functional teams (HPX_fT) in construction is likely to be commercially motivated, “the pay-off must be financial in the first instance and will only come when team working results in each business firm represented receiving the profit it expected”, [11].

2.2 Performance Management

For Katzenbach and Smith [12], the definitive characteristic that distinguished a group, taskforce, alliance or any other socially inclusive working party from a team is – performance. Historically, organisational performance has focused first and foremost on the financial criteria of company profit. This restricted outlook to corporate performance has over the years, received numerous criticisms for “emphasising economy and efficiency and neglecting measures of customer satisfaction and quality”, [13]. This parochial outlook fulfils a buildability criterion with respect to economies and efficiencies of production but is of limited consequence for the end user, consumer and/or customer with interests in effectiveness and ethics. A contemporary perception of performance management may be expressed as a holistic concept, widening the focus of performance measurement techniques to include traditional as well as contemporary performance dimensions. In response to this need to diversify whilst at the same time encapsulates a range of performance measurements that would better represent corporate well-being, Kaplan and Norton developed the ‘Balanced Scorecard’ concept. The assertion of the balanced scorecard was to construct a set of four inter-related criteria that would give senior managers a fast and comprehensive information model that would be representative of corporate strategy, objectives and competitive demands. The balanced scorecard supplements the financial outlook of corporate performance with three other business viewpoints; customer perspective, internal business perspective and an innovation and learning perspective. The four perspectives create a more ‘rounded’ approach to company performance appraisal, acknowledging the importance of the various stakeholders. Kaplan and Norton [14], stress that the balance scorecard presents a cross-functional shortlist of key indicators for present and future performance. Whereas, financial information on its own is backward looking, reflecting on previous performance without predicting future achievements.

2.3 Performance Management of Teams

Research has indicated that although performance management is widely accepted as a prerequisite of corporate well-being, little has been done to assimilate and customise ‘individualistic’ performance management principles to meet the demands of a team orientated ‘collectivism’ environment. “One of the interesting findings of our research was that…relatively few organisations made specific arrangements for team performance management”, [15]. This comment concurs with Staniforth’s [16] observations relating to staff appraisal policy, where he states, “there is little evidence to suggest that anything other than ‘individual appraisal’ is done”, raising the question, “do we really appraise team work, or just individuals who work in teams”. Staniforth concludes by observing “many UK organisations do not yet appear to have broken the shackles of an individualistic approach to work”.

3. Methodology

3.1 Overview

The research methodology employs two independent techniques for data collection. The team rating is obtained via a team attitude statement questionnaire distributed to all participating construction site team members. Project performance is calculated by identifying key project performance data requirements and benchmarking the results using selected key performance indicators, advocated by Constructing Excellence, [17].

3.2 The Team Questionnaire

The team questionnaire is derived from the initial team literature search and reflects the recurring themes that punctuate team related discussion. Three broad categories are identified that provide a balance to the individual variable(s) that would be used for the evaluation of the construction team rating. Team Compatibility and Diversity is used as a heading to embrace four distinct variables associated within this theme; 1/ Interdependency, 2/ Membership Diversity, 3/ Team Dynamic and 4/ Trust. This category relates to a personal and management awareness of working together and the application of personality inventories developed to assemble individuals who will compliment the functioning of the group in both a professional and behavioural perspective. The second category identified was Organisational Context; this section recognises the potential influence company systems may have on the outcome of team working practices. This category consists of two variables entitled 5/ Corporate Intent and 6/ Policy, Procedures and Customs. The third category ‘Industry Context’ was introduced to represent the established convention that construction is a ‘team game’ and as such may have a subliminal impact on employees working within this environment. Industry context has one variable, 7/ Culture. The team questionnaire has eight sections; one for each of the seven variables identified and an eighth section related to general information that will contribute to project performance measurement. The questionnaire seven team sections employ a rating system whereby the respondent is offered a choice of five possible responses and asked to select the one that best reflects their judgement. The five options are: ‘Completely True’, ‘Mostly True’, ‘Partly True’, ‘Slightly True’ and ‘Never True’. The given response is then translated to a score of 5 – to – 1 respectively (Likert Scale), calculated as a percentage and plotted on the appropriate axis of the ‘Team Rating Radar Chart’. An average construction site team rating is calculated from the seven individual variables.

3.3 Project Performance Toolkit

The project performance toolkit is a customised suite of seven industry recognised key performance indicators (KPI) that provide an all-inclusive snapshot of project performance. In an attempt to capture a more ‘rounded’ examination of project performance Kaplan and Norton’s balanced scorecard concept was utilised as a template for KPI selection. This required addressing the four specific perspectives of contemporary performance measurement, 1/ the financial perspective, 2/ the customer perspective, 3/ the internal perspective and 4/ the innovation & learning perspective. A number of secondary issues that would facilitate the administration of the performance toolkit were also taken in to consideration such as: holistic measurement; KPI adaptability; data and source availability; validity and reproducibility. The performance indicators selected all come from the current (2004) key performance indicators endorsed by Constructing Excellence. The seven selected indicators comprise of four KPI’s from the ‘All Construction’ suite and three KPI’s from the ‘Respect for People’ suite of KPI’s. They are:

Key Performance Indicator (KPI)		Balanced Scorecard Perspective
1/ Predictability	– Construction Cost	(Financial)
2/ Predictability	– Construction Time	(Financial)
3/ Client Satisfaction	– Service	(Customer)
4/ Client Satisfaction	– Product	(Customer)
5/ Employee Satisfaction		(Internal)
6/ Working Hours		(Internal)
7/ Training		(Training & Innovation)

The project data is pooled from three different sources: Predictability – Construction Cost & Predictability – Construction Time is provided by the construction site team leader, typically the project manager. The client or client’s representative is given a short questionnaire to complete regarding service and product satisfaction. Information regarding employee satisfaction, working hours and training is all provided by the construction site team participants, section eight of the team questionnaire. The collated project responses can then be calculated and converted in to benchmark percentages using the appropriate KPI data sheets. The information is then plotted on the appropriate axis of the project performance radar chart with an average project performance calculated from the seven individual results.

4. Case-Study

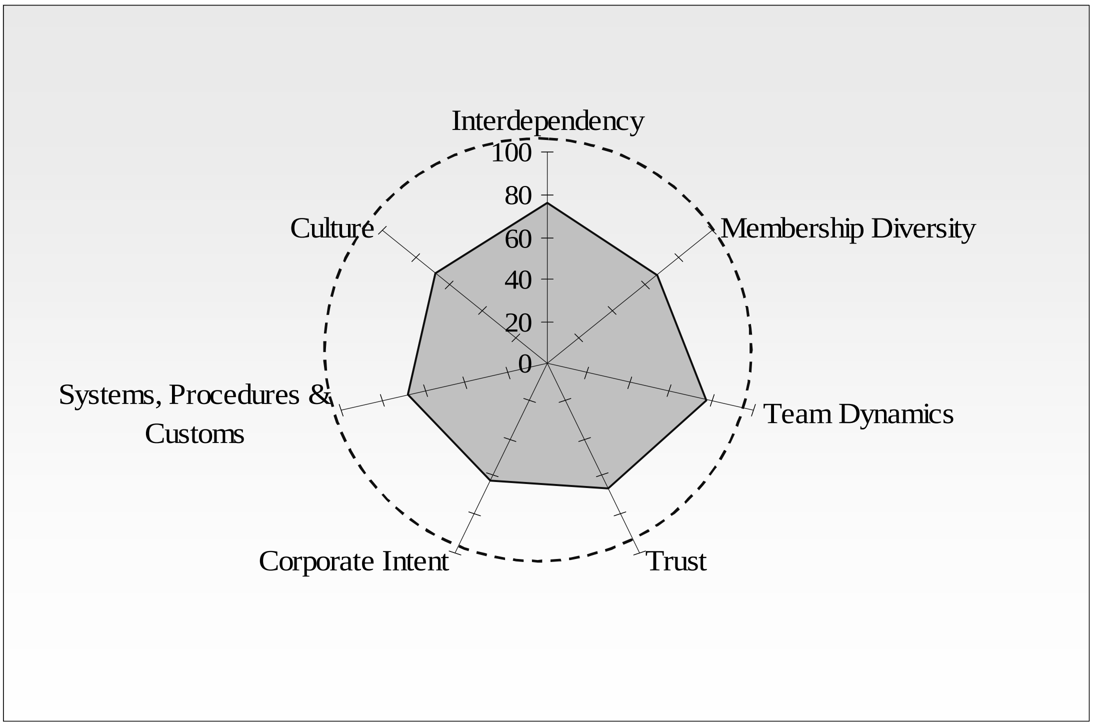
4.1 Overview

The following case-study was carried out between August and September 2004 with the help and cooperation of a major UK contracting organisation with a combined corporate turnover in excess of £1.47 billion. The Scottish regional office provides contracting services across the central belt and is a division of the largest business sector within the group, contributing to an annual sector turnover of £787.6 million. Five construction projects within the Scottish region where selected as suitable for this case-study. The projects varied in valuation, ranged from £2.9m to £9.2m. There was also a cross representation of procurement routes, clients (private and public) and building type. Project 1/ is a £9.2 million conversion project of a city centre, category 'A' listed building. Project 2/ is a new build children's hospice. The £6.3 million development will provide respite care and accommodation for family members, an education suite, day facilities and play areas. Project 3/ is a £8.5 million contract involving a combination of new build and refurbishment work. The refurbishment is a swimming pool with the development of a new adjoining arts centre. Project 4/ is a £2.9 million environmentally friendly, bespoke community building comprising of offices, café and crèche facilities. Project 5/ is another local community project, a state-of-the-art building comprising library, IT facilities, fitness suite and cafe with a contract value of £3 million.

4.2 Results

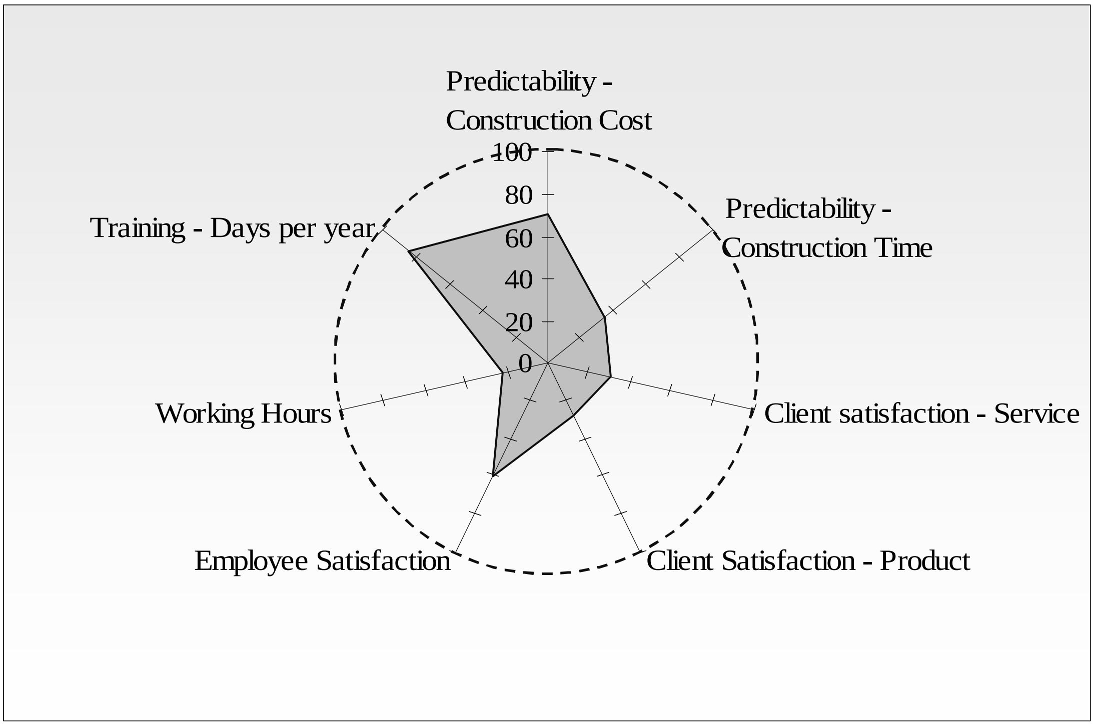
Table 1/ illustrates the individual project results along with a company average for both the 'Team Rating' and corresponding 'Project Performance'.

Project No.:	Team Rating	Project Performance
Project 1/	72% (rank 2nd.)	54% (rank 2nd.)
Project 2/	68% (rank 4th.)	47% (rank 3rd.)
Project 3/	62% (rank 5th.)	29% (rank 5th.)
Project 4/	70% (rank 3rd.)	42% (rank 4th.)
Project 5/	74% (rank 1st.)	61% (rank 1st.)
Company Average:	**69%**	**47%**



Ave. Team Rating = 69%
Standard Deviation = 5.4

Fig. 1: Team Rating Radar Chart (Company Average)



Ave. Project Performance = 47%
Standard Deviation = 24.1

Fig. 2: Project Performance Radar Chart (Company Average)

Note: The results are presented using a radar Chart format. In general, the nearer the plotted line is to the outer perimeter of the radar chart, the higher the overall rating / performance.

Table 2/ is a breakdown of the seven-team variable averages from the five construction projects participating in the case-study:

Team Variable	Team Category	Score
1/ Interdependency	(Group Diversity & Compatibility)	- 76%
2/ Membership Diversity	(Group Diversity & Compatibility)	- 67%
3/ Team Dynamics	(Group Diversity & Compatibility)	- 77%
4/ Trust	(Group Diversity & Compatibility)	- 66%
5/ Corporate Intent	(Organisational Context)	- 62%
6/ Systems, Policies & Customs	(Organisational Context)	- 68%
7/ Culture	(Industry Context)	- 68%

Table 3/ is a breakdown of the seven project KPI average score from the five construction projects participating in the case-study:

Indicator		Perspective	Company Score
1/ Predictability - Construction Cost	(%)	(Financial)	0%
2/ Predictability - Construction Time	(%)	(Financial)	+11%
3/ Client Satisfaction – Service	(out of ten)	(Customer)	7.2
4/ Client Satisfaction – Product	(out of ten)	(Customer)	7.2
5/ Employee Satisfaction	(out of ten)	(Internal)	6.9
6/ Working Hours	(per week)	(Internal)	48.5
7/ Training Days	(per year)	(Innovation & Learning)	3.8

Table 4/ transfers the project KPI average score in to KPI Construction Industry Benchmarks percentage:

Key Performance Indicator	Perspective	Benchmark Score
1/ Predictability - Construction Cost	(Financial)	- 70%
2/ Predictability - Construction Time	(Financial)	- 34%
3/ Client Satisfaction - Service	(Customer)	- 31%
4/ Client Satisfaction - Product	(Customer)	- 28%
5/ Employee Satisfaction	(Internal)	- 60%
6/ Working Hours	(Internal)	- 22%
7/ Training - Days per year	(Innovation & Learning)	- 84%

Note: The project performance results are all from the relevant Headline Construction Performance Benchmark for 2004. KPI 1/ to 4/ is taken from the All Construction suite and KPI 5/ to 7/ is taken from the Respect for People suite.

5. Analysis

A number of important issues need to be clarified prior to the interpretation of the results. At present the case-study company does not employ the current Key Performance Indicators (KPI's) developed by the DTi. In the application of performance management is it fundamental that the participants are fully aware of the standard against which they will be measured, this information permits the targeting of resources in to areas that will contribute to the final evaluation of the project. At the time of the study, all five case-study participants where unaware of the measures against which the site performance was being evaluated for this study. Therefore, due to likely deviations between current company performance measures and those used for the purpose of the research it would be unreasonable to interpret project outcomes' in terms of good or bad. They may be used in comparison with other sites and/or as a starting point for future company benchmarking initiatives. With regard to the KPI Benchmark scores it is important to be aware that initial scores that appear better than average may translate to KPI Benchmark percentages that are in general terms poorer, simply because construction industry standards within that particular sphere are, in relative terms, high. For example, a Client Satisfaction (Product) score of 7 out of 10 may be viewed as above average, i.e. 70%. Translated in to the KPI benchmark a score of 7 equates to a benchmark result of 20%. Meaning that 20% of projects are achieving equal or lower performance and 80% are achieving a higher performance.

5.1 Team / Project Relationship

Three statistical techniques where carried out to ascertain an empirical link between the two project variables. A student's two-tailed t-test of the research hypothesis; H_o = 'construction site teams influence project performance' was accepted with a 95% confidence limit, signifying that the association between the two variables is significant. This result is corroborated by a Pearson's correlation coefficient of +0.95. Again, this figure demonstrates a very strong link between the two principle project variables. The coefficient of determination (RSQ) of Pearsons correlation indicates that the level of association may be as high as 90%. Although the project performance may vary for many reasons, it would appear that in this study 90% of the variation in project performance can be attributable to differences in the team rating. Note, due to the very small sample size further case-studies are required and more rigorous statistical analysis undertaken to develop confidence in the patent cause and effect relationship of team working and project performance. At present, the initial findings suggest a significant level of association.

5.2 Company Results

Within the Team Performance there are two notable highs. Interdependency and Team Dynamics both from the Group Diversity & Compatibility category scored 76% and 77% respectively. This relates to team awareness for the need to work together, acknowledging that success is dependent on a collaborative effort. Team dynamic relates to team size and frequency of communication, formal and informal between team members. Due to the small team compositions, for example the largest participating team size was five members, it may have been predicted that the variable(s) associated with degree of understanding and interaction would score highly. The notable weakness is Corporate Intent with a company average of 62% (Organisational Context). This variable measures an employees' consciousness of team working philosophies as an integral character of company strategy. It may be that team working is taken as customary for the construction industry environment, for example Culture recorded an average of 68% and therefore corporate team training may be overlooked as an explicit business practice for improving company results. The relationship between average team ratings and corporate intent are an exact match with their respective ranking, highest to lowest producing a Pearson product moment of correlation coefficient of +0.95.

Table 5 illustrates the relationship between average team ratings and associated values for the variable 'Corporate Intent' (Organisational Context).

Project No.:	Team Rating	Corporate Intent Variable
Project 1/	72% (rank 2nd.)	64% (rank 2nd.)
Project 2/	68% (rank 4th.)	56% (rank 4th.)
Project 3/	62% (rank 5th.)	52% (rank 5th.)
Project 4/	70% (rank 3rd.)	62% (rank 3rd.)
Project 5/	74% (rank 1st.)	77% (rank 1st.)

Other possible influences could be the high labour turnover and/or recently employed team members. Analysis of the team member questionnaire(s) highlighted a number of recently employed members. The average length of service for site team participants is fifteen months with three of the projects averaging less than twelve months. The project with the highest average team rating had an above average employment statistic of eighteen months. At the lower end of the team ratings, project 2/ and project 3/ had below average figures of four and nine months, ranked 4th and 5th respectively. Another variable very much associated with team awareness at a tactical level is 'trust', recording an average company rating of 66%. It is widely recognised that trust evolves over time spent working in a co-dependent environment. Casual observation of the average project team rating and values attributed to the trust variable demonstrate a similar pattern of lowermost trust values associated with a poorer team rating average, (see table 6).

Table 6/ illustrates the relationship between average team ratings and associated values for the variable 'Trust' (Group Compatibility and Diversity).

Project No.:	Team Rating	Trust Variable
Project 1/	72% (rank 2nd.)	70% (rank 2nd.)
Project 2/	68% (rank 4th.)	63% (rank 4th.)
Project 3/	62% (rank 5th.)	53% (rank 5th.)
Project 4/	70% (rank 3rd.)	73% (rank 1st.)
Project 5/	74% (rank 1st.)	69% (rank 3rd.)

A Pearson product moment of correlation coefficient of +0.90 suggests that the levels of trust within the broad team dynamic may be a core variable, influencing the overall perception of team working and perceived personal well-being between the participants. Again, an itinerant workforce with transient team formations may suppress the development of trust between the team members, inhibiting the transition of group work to team work or team work to high performance teams. Company averages for Project Performance highlight a number of interesting points. The most noteworthy strong point across all the projects studied was 'Training – days per year.' A KPI of 84% was recorded indicating that only 16% of UK construction companies perform better. The lowest KPI score was 22% for 'Working Hours', suggesting that 78% of construction company employees have shorter working weeks. The company average working week for site-based staff employees is 48.5 hours per week. This was consistent across all the projects studied. This may be due to site and/or programme circumstances but other reasons could exist and may be worth investigating in an effort to improve the work – life balance. An interesting detail from analysis of the KPI's is the lower than expected benchmark scores for 'Client Satisfaction – Service and Product'. Both recorded a respectable company average of 7.2 out of 10 from the Client / Client Representative Questionnaire, this translates to KPI scores of 31% and 28% respectively. The result is a potentially motivating outcome because small gains in client perspective would convert to significant improvements in KPI scores. For example, a gain of 0.8 points (7.2 to 8.0) would mean an increase of 24% and 27% to a KPI of 55% for both service and product.

6. Conclusions

From the results of this construction company case-study it may be concluded that enhanced levels of team working significantly influences project performance. The positive correlation in itself is not necessarily unforeseen but the potency of the relationship between the two variables is surprising. The significance of the case-study results encourages the development of a construction team - performance diagnostic toolkit that would 1/ encourages companies to benchmark their project performance, 2/ evaluate performance against current levels of team efficiency and 3/ help align HRM policies to compliment a team orientated environment. By targeting the weaker team variables highlighted by the diagnostic toolkit, High Performance Cross-Functional Team (HPX_fT) working may become a more realistic and achievable objective. In addition, the toolkit also highlights organisational strengths and weaknesses as well as distinct project team - performance issues that can be addresses in the movement for best practice and construction excellence. In short, the research programme demonstrates that if realised, the team 'works'.

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Sharing Knowledge across Professional Boundaries: A Case Study in a Government Department

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Abstract

Today, knowledge is an important asset in most organizations, enabling them to cope with the changing environment and increase their efficiency. Through inter-disciplinary knowledge sharing, organizations can utilize the competence and knowledge of their staff. This is also true for different construction professionals working on the same project, but knowledge sharing across professional boundaries does not come naturally.

Recognizing the need for research into this area, this study explored inter-disciplinary sharing practices in the Architectural Services Department (ArchSD) of the Government of the Hong Kong Special Administrative Region. A survey was conducted to find out the frequency, channels and types of knowledge shared across professional disciplines. Findings indicate that professionals do share frequently with other professionals in terms of project, procedural, and operational and maintenance knowledge through a variety of channels. Email, informal discussions and formal project meetings are the most popular of these. Sharing knowledge helps professionals to make decisions and solve problems in their daily professional work.

Keywords: Knowledge sharing, professional boundaries, public sector, inter-disciplinary

1. Introduction

For years, competition has been the great motivator of our economic system. However, facing the increasingly competitive market and the tremendous amount of information made available, organizations' competitiveness may decrease if the knowledge bases of their employees cannot be fully utilized.

In construction projects, professionals from different disciplines work together to achieve the objective of completing a successful project. The interdisciplinary nature of the work involves frequent communication and sharing among different project participants. The vast amount of information and knowledge required in projects needs proper communication and cooperation among various professionals.

Inter-disciplinary knowledge sharing can be a solution to our fragmented project-based construction industry. Through proper sharing, knowledge and experience is transferred among professionals of different disciplines. By using knowledge sharing channels such as the Internet, e-mail, intranet, documents or face-to-face meetings, information and knowledge is made available to individuals within a department, a project team or even within an entire organization.

In previous research, there has been a lack of studies on inter-disciplinary knowledge sharing in the public sector. The Architectural Services Department (ArchSD) of the Hong Kong Special Administrative Region (HKSAR) is chosen as the research case because of its relatively large organization size and the fact that it comprises construction professionals from different disciplines.

This research has the following three objectives:

- To identify the frequency of and need for inter-disciplinary knowledge sharing.
- To investigate current knowledge sharing channels and their effectiveness within ArchSD.
- To analyze the types of knowledge shared among various professionals within ArchSD.

2. Inter-disciplinary Knowledge Sharing

Knowledge sharing is a mechanism installed to encourage the sharing of expertise throughout an organization [1]. Knowledge begins with the individual, with new brilliant ideas or fruitful experience. It then comes to the central activity of making personal knowledge available by sharing it with others. This takes place continuously and among professionals of the same and/or different disciplines.

When knowledge is shared across the professional boundaries between different professionals, this type of sharing is identified as ‘inter-disciplinary knowledge sharing’. Professionals can share their own disciplinary knowledge, general knowledge or past project experience. With this kind of knowledge sharing, professionals can solve problems more effectively and readily with others, as Kjellin and Stenfors [2] and Traunmuller and Wimmer [3] suggest. Both tacit and explicit knowledge can be shared in inter-disciplinary knowledge sharing. However, explicit knowledge can be retrieved and transmitted more easily than tacit knowledge [1].

As listed in Table 1, different sharing channels are developed to gather, organize, distribute and share knowledge among professionals throughout an organization. Traditional sharing channels used are documentary records, meetings and direct discussion. In the last decade, with the development of information technology, some new channels such as email and database have been developing rapidly, and it is believed that they will play a major role in the future.

Table 1: Knowledge sharing channels

Knowledge Sharing Channels	
▪ **Documentary**	Memoranda and letters
	Project records
	Internal newsletter and circulars
▪ **Direct discussion**	Formal project meetings
	Informal discussions
	Talks and seminars
▪ **Technological**	Database
	Email
	Internet
	Intranet
	Teleconferencing

Everybody has knowledge useful to somebody else within an organization. Inter-disciplinary knowledge sharing helps individual professionals specialized in certain disciplines to exchange relevant knowledge and experience with specialists of other domains. Huysman [4] indicates that sharing supports the goals in mind of acquiring knowledge, reusing knowledge and developing new knowledge. Effective sharing channels can reduce areas and time people spend on looking for relevant information and knowledge. Thus, individuals' productivity is enhanced.

Knowledge sharing also benefits entire organizations by enhancing the efficiency and effectiveness of the work performed. With knowledge sharing, the problems of an organization in re-learning lessons, repeating mistakes, reinventing solutions or recreating knowledge that already existed in the mind of another professional, as suggested by Seeley [5], will be solved. So, the better the organization can recognize its employees' expertise, the better it is at making decisions and maintaining competitiveness, no matter whether in the public or private sector [6].

Although all construction projects have unique features, some typical problems are frequently repeated. For example, poor logistics co-ordination has led to time and material wastage. And criticism of a design's buildability, poor project management and contractual disputes are common [7]. If knowledge sharing is promoted in the construction industry, problems in one project would be the teachers for the next one. Knowledge sharing is thus an effective and proactive way to prevent problems from happening again. This helps to solve the problem of un-recycled knowledge mentioned by Awad and Ghaziri [1].

3. Case Organization

The Architectural Services Department was established in April 1986 to provide a comprehensive range of multi-disciplinary professional and technical services to the HKSAR Government and quasi-government organizations. Its mission is to provide services in a professional manner. There are six branches under the ArchSD: the Project Management Branch, the Architectural Branch, the Building Services Branch, the Structural Engineering Branch, the Quantity Surveying Branch and the Property Services Branch.

The ArchSD is responsible for the design and construction of government buildings and facilities, as well as those of subvented organizations like the Hospital Authority. It also provides associated professional services related to engineering, planning, landscaping, and the maintenance and repair of buildings. Within ArchSD, there are about 2000 posts that are composed of directorate, professional, technical, site and general staff. Professionals from various disciplines work together to provide for the comprehensive functioning of the department's services. The variety of services of the ArchSD also requires professionals to cooperate and coordinate intra-disciplinarily and inter-disciplinarily. In this way, the department's mission of providing services in a professional manner can be achieved.

4. Research Methodology

4.1 Sample and Data Collection

In this study, quantitative analysis is adopted as the objective of the study is to investigate knowledge sharing practices among different professionals in ArchSD. Feedback from a number of respondents from different disciplines is required in order to draw up a clear and broad view of the overall situation. A questionnaire survey was implemented due to the following reasons:

- Easier to reach a larger number of respondents,
- More convenient for respondents to fill in compared with lengthy face-to-face interviews,
- No interview bias,
- Less chance of feeling embarrassed, as some questions are personal.

The purpose of the questionnaire survey was to find out the current inter-disciplinary knowledge sharing practice in the ArchSD, with special emphasis on the sharing channels. A 6-point scale was used as the weighting order for questions concerning the tendency and attitudes of respondents.

4.2 Questionnaire Administration

The target population was selected by random sampling of the staff list of the Government of the Hong Kong Special Administrative Region. According to the job functions in the Architectural Services Department, 50 professionals were randomly drawn from each of the five disciplines, namely architectural (Arch), building services engineering (BSE), maintenance surveying (MS), quantity surveying (QS) and structural engineering (SE). A total of 250 questionnaires were sent with stamped return envelopes to stimulate an acceptable response rate.

4.3 Response Rate

The number of responses and corresponding response rate are listed in Table 2 according to the job function classification. Out of the 250 questionnaires sent to the ArchSD, 95 valid questionnaires were returned (response rate = 38%). According to Black et al. [8], typical response rates in research in the construction industry are around 30%. Thus the response rate in this research is satisfactory and acceptable.

5. Data Analysis

Data were analyzed using descriptive statistics such as percentages and frequencies to present the sample characteristics such as job function and work experience in the ArchSD. Further descriptive statistics of mean and standard deviation (SD) were used to present the preferences and tendency of respondents in terms of their main attitude towards knowledge sharing practices and channels.

5.1 Respondents' Background

Table 2 shows the distribution of respondents according to their job functions. About 30% of the respondents were in the maintenance surveying profession, while quantity surveying professionals only accounted for 15.8%. Architecture, building services and structural engineering professionals have the same percentage: 17.9% of all survey respondents.

Table 2: Response rate according to job function

Job Function	No. Forwarded	No. of Responses (Valid)	Response Rate	% of Overall Responses
Architecture	50	17	34%	17.9%
Building Services Engineering	50	17	34%	17.9%
Maintenance Surveying	50	29	58%	30.5%
Quantity Surveying	50	15	30%	15.8%
Structural Engineering	50	17	34%	17.9%
Total	250	95	38%	100.0%

From Table 3, over 85% respondents had 6 years' experience or more, while professionals with over 10 years' experience accounted for 55.8%. Due to the reduction in new recruitment in the ArchSD in recent years, no respondents had 3 years' experience or less. This means that the survey findings tend to reflect the attitudes of experienced professionals.

Table 3: Distribution of work experience of respondents

Work Experience in ArchSD	Frequency	Percentage
Less than 3 years	0	0%
3 - 6 years	14	14.7%
6 - 10 years	28	29.5%
More than 10 years	53	55.8%
Total	95	100.0%

5.2 Frequency of and Need for Inter-disciplinary Knowledge Sharing

As Table 4 reveals, the mean scores of inter-disciplinary sharing frequency are all above 4, showing that inter-disciplinary knowledge sharing is quite common in the ArchSD. The highest mean score was for sharing with architects, which is not surprising as they are responsible for the design and are in charge of the whole construction process. Different professionals need to refer to the architects to clarify and interpret drawings and answer queries. The high sharing frequency with architects and building services engineers also reflects the complexity of their tasks, which require frequent coordination.

The mean score is the lowest with the maintenance surveying profession. This result is consistent with real life, in which their work nature requires less sharing with other professions. This is because of their job function, which deals mostly with alterations and maintenance. Their involvement in projects is more independent and requires less sharing with other colleagues during the project lifecycle. Nevertheless, they still need to collaborate with other project team members in order to carry out their jobs properly.

Table 4: Percentage and mean of sharing frequency with different disciplines

Sharing Frequency with	6	5	4	3	2	1	Mean	SD
Arch	23.25%	26.75%	24.41%	16.28%	8.14%	1.16%	4.37	1.29
BSE	20.96%	30.12%	16.31%	22.12%	8.15%	2.33%	4.27	1.36
MS	29.71%	19.31%	19.31%	4.46%	12.34%	14.86%	4.06	1.82
QS	15.73%	29.27%	26.83%	10.97%	9.81%	7.38%	4.17	1.37
SE	17.65%	21.18%	35.29%	11.77%	9.41%	4.70%	4.12	1.36

(6 = Always; 1= Seldom)

The sharing need shows a similar distribution pattern as the sharing frequency, with the mean above 4 (Table 5). The highest mean score is obtained from sharing with architects, indicating how important it is for architects to communicate with and provide information to other professionals.

Table 5: Percentage and mean of need to share with different disciplines

Need of Sharing with	6	5	4	3	2	1	Mean	SD
Arch	21.94%	28.05%	30.49%	12.20%	6.09%	1.22%	4.44	1.21
BSE	20.73%	29.27%	23.17%	18.29%	7.32%	1.22%	4.34	1.27
MS	28.36%	17.91%	23.88%	14.93%	8.96%	5.97%	4.24	1.53
QS	14.29%	22.08%	36.36%	11.69%	11.69%	3.90%	4.14	1.32
SE	15.66%	22.89%	32.53%	13.26%	14.46%	1.20%	4.08	1.30

(6 = Very High; 1 = Very Low)

5.3 Frequency of Sharing Channels Used

As Table 6 shows, email is the most popular and frequently used channel in knowledge sharing in the ArchSD (mean = 4.80), which is unsurprising as it is fast and user-friendly. However, the use of other information technology is not common. The Internet (mean = 3.80), databases (mean = 3.00) and teleconferencing (mean = 1.99) are rarely used in the ArchSD. This shows that the advantages of information technology as a 'knowledge enabler' in sharing, as suggested by Awad and Ghaziri [1], are not fully utilized in the ArchSD.

The high ranking of informal discussion (mean = 4.68) and formal meetings (mean = 4.58) shows that channels involving direct communication and interaction are also popular in the ArchSD, in both formal and informal ways. Meetings provide a good opportunity for different professionals to share knowledge, receive feedback and observe non-verbal clues from project members. However, the frequency of formal meetings is highly dependent upon an individual project's or organization's requirements. Even though professionals find them effective, individuals cannot control the frequency of meetings.

Table 6: Frequency of using different sharing channels

Frequency	6	5	4	3	2	1	Mean	SD	Rank
Database	4.54%	14.77%	23.87%	12.50%	21.59%	22.72%	3.00	1.55	10
Email	30.85%	38.29%	20.21%	3.19%	5.32%	2.13%	4.80	1.20	1
Formal project meeting	18.28%	35.49%	34.41%	9.67%	2.16%	0.00%	4.58	0.97	3
Informal discussion	23.16%	36.84%	30.53%	4.21%	5.26%	0.00%	4.68	1.04	2
Internet	4.44%	14.44%	16.67%	16.67%	17.78%	30.00%	2.81	1.59	12
Intranet	13.97%	29.07%	21.49%	8.60%	11.82%	15.05%	3.80	1.66	6
Internal newsletter and circulars	10.64%	22.34%	23.40%	19.15%	8.51%	15.96%	3.60	1.57	8
Internal training courses	3.16%	22.11%	34.74%	20.00%	11.57%	8.42%	3.60	1.27	8
Other meetings	14.78%	32.44%	28.49%	15.83%	6.34%	2.12%	4.27	1.20	5
Memoranda and letters	20.21%	30.85%	23.41%	15.96%	5.32%	4.25%	4.32	1.34	4
Talks and seminars	3.16%	23.12%	35.81%	21.06%	13.69%	3.16%	3.72	1.15	7
Teleconferencing	4.65%	5.81%	5.81%	9.30%	16.28%	58.14%	1.99	1.48	13
Others	12.49%	0.00%	12.49%	12.49%	0.00%	62.54%	2.25	1.91	11

(6 = Always; 1 = Never)

5.4 Effectiveness of Sharing Channels

Similar to the frequency distribution of channels, informal discussion, formal meetings and email are the top three most effective sharing channels used by the respondents (Table 7).

During meetings, professionals can share knowledge effectively by expressing opinions and ideas to the team directly. This helps in the collective evaluating and redesigning of new knowledge to the team. Some formal meetings such as project review meetings and project briefing sessions can generate new ideas and provide lessons learned to project participants, which can achieve the aim of knowledge sharing. Informal discussion allows people to discuss issues in a more informal and relaxed environment compared with formal project meetings, as taking minutes can have a “backfire” effect on open sharing. Email as a communication channel does not provide a rich source of interaction, and the meaning of an email can easily be misinterpreted by its receivers as it lacks non-verbal clues.

Table 7: Effectiveness of using different sharing channels

Effectiveness	6	5	4	3	2	1	Mean	SD	Rank
Database	4.76%	25.01%	23.81%	11.91%	14.28%	20.23%	3.33	1.59	11
Email	23.92%	46.74%	18.48%	5.43%	3.26%	2.17%	4.76	1.11	2
Formal project meeting	23.08%	37.36%	27.47%	10.99%	1.10%	0.00%	4.70	0.98	3
Informal discussion	23.66%	45.16%	18.27%	10.76%	2.16%	0.00%	4.77	1.00	1
Internet	8.34%	22.62%	17.86%	15.47%	13.10%	22.62%	3.30	1.68	12
Intranet	14.44%	32.23%	26.67%	5.55%	8.89%	12.22%	4.01	1.56	7
Internal newsletter and circulars	10.22%	20.46%	31.82%	19.32%	7.96%	10.22%	3.75	1.42	10
Internal training courses	7.61%	31.53%	34.78%	13.04%	5.43%	7.61%	4.00	1.29	8
Other meetings	17.20%	32.26%	33.33%	11.83%	2.16%	3.23%	4.40	1.16	4
Memoranda and letters	19.56%	27.17%	31.52%	15.22%	4.35%	2.18%	4.36	1.21	5
Talks and seminars	8.69%	31.56%	29.33%	22.82%	4.34%	3.26%	4.08	1.17	6
Teleconferencing	6.25%	7.51%	11.25%	11.25%	11.25%	52.51%	2.29	1.65	13
Others	33.39%	16.61%	16.61%	0.00%	0.00%	33.39%	3.83	2.32	9

(6 = Most Effective; 1 = Least Effective)

As Table 8 reveals, the ranking of the effectiveness of different channels is similar to the ranking of their frequency of use. This suggests that the use of sharing channels is quite successful in the ArchSD, as the frequently used channels are also the effective ones. Actually, the frequency and effectiveness are closely related. Channels such as databases and teleconferencing are not classified as effective, as they are rarely used.

Table 8: Ranking of frequency and effectiveness of different sharing channels

Sharing Channels	Frequency Ranking	Effectiveness Ranking
Database	10	11
Email	1	2
Formal project meeting	3	3
Informal discussion	2	1
Internet	12	12
Intranet	6	7
Internal newsletter and circulars	8	10
Internal training courses	8	8
Other meetings	5	4
Memoranda and letters	4	5
Talks and seminars	7	6
Teleconferencing	13	13
Others	11	9

5.5 Types of Knowledge Shared

Through the use of different sharing channels, different types of knowledge can be shared (Table 9). It is not surprising that project knowledge is the type most frequently shared among different disciplines (mean = 5.02), while product knowledge scores the lowest mean of 3.73. Procedural knowledge is ranked second, as each organization or department has its own procedures or routines to follow. Operation and maintenance knowledge ranks third, as a properly designed facility also needs to consider future maintenance issues: no facility is maintenance-free. In addition, operation knowledge provides the comfort that people truly desire when a facility is in operation.

Concerning product knowledge, the architectural and maintenance surveying professions rate this much higher than other professions. This is due to their work nature. Architects are involved with the aesthetic issues of a project, and maintenance surveyors work on the compliance with building requirements and maintenance of facilities.

Table 9: Mean scores of different knowledge types shared among disciplines

Types of Knowledge Shared	Job Function					Overall
	Arch	BSE	MS	QS	SE	
Project knowledge	5.18	5.35	5.00	4.93	4.65	5.02
Operation and maintenance knowledge	4.35	4.59	4.97	3.13	3.88	4.18
Procedural knowledge	4.47	5.00	4.79	4.67	3.76	4.54
Process knowledge	4.00	4.53	4.41	3.73	3.76	4.09
Product knowledge	4.29	3.65	4.24	3.07	3.41	3.73

(6 = Always; 1 = Never)

6. Conclusions and Recommendations

The purpose of this research was to study the knowledge sharing of professionals of different disciplines in the Architectural Services Department. In the construction industry, the different professionals have their own expertise. However, they need to share knowledge, experience and information with other project team members in order to perform their jobs properly. Otherwise, the construction industry does not need to call on such a wide spectrum of specialization.

The survey findings indicate that most of the professionals in the ArchSD need knowledge sharing, though such sharing is less practiced with maintenance surveying professionals due to the lower demand for sharing in their work environment. Different types of knowledge, such as operation and maintenance knowledge, procedural knowledge and product knowledge are shared. Among them, project knowledge, including project designs, contractual arrangements, management experience and skills, etc., is the most frequently shared. In addition, project-organizing knowledge is also required, as managing a construction project is a complex business.

To cope with the need for sharing and to enhance the benefits of sharing, different sharing channels are developed. These range from traditional documentary records and meetings to newly developed information technological systems and networks. The findings of this research show that email, formal meetings and informal discussion are the most frequently and effectively used sharing channels. A close relationship between the frequency and effectiveness of sharing channels is noted. Professionals prefer to use traditionally effective channels. Some newly developed channels, such as databases and teleconferencing, are rarely used, and hence are not seen to perform effectively. There is room to develop the use of such new channels. Although the research findings are based on a particular government department, it is believed that similar conclusions can be applied to other types of organizations within the construction industry.

Based on the survey analysis, the following recommendations are made to the Architectural Services Department. They can also be applied to other organizations, subject to careful consideration to suit their own situations.

- It is found that newly developed information technology such as databases and intranets are not extensively utilized in the ArchSD. Developing sharing channels such as setting up project-based intranets, extranets or information platforms is recommended, as they help to cope with the increasing demand for sharing and follow the development of IT in society. In addition, a properly designed intranet enables knowledge to be captured and form part of the organization's memory system, as it enhances information searching and re-use abilities.

- To develop knowledge sharing, emphasis should not be purely on documentation, rules and procedures. Rather, human issues, cultivating a sharing culture and increasing trust among staff are more essential for successful knowledge sharing.

- The department should develop a common consensus with the staff that knowledge sharing cannot be developed overnight. The same rule applies to the benefits that are obtained from knowledge sharing. Resources are spent at first to develop sharing channels and overcome difficulties. However, the final outcome of being an effective and efficient organization utilizing its knowledge base is the best reward. This is especially true in the construction sector, where close cooperation and frequent sharing among different disciplines is an absolute requirement to solve problems in individual projects as well as for the entire industry.

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